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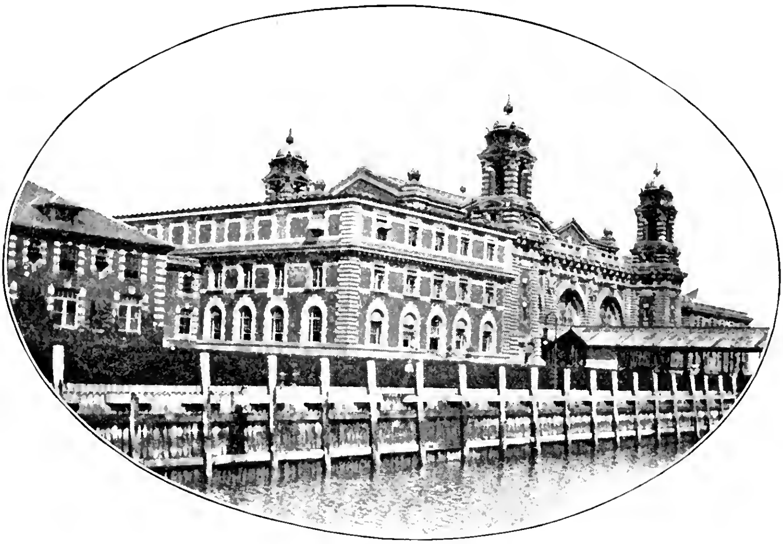
GOING THROUGH ELLIS ISLAND

By DR. ALFRED C. REED

U. S. PUBLIC HEALTH SERVICE, ELLIS ISLAND

IT is at least a question whether the visitor to Ellis Island looks at the newly landed immigrant with eyes any more curious than those with which the immigrant looks at the visitor. The one sees the timidity, the surprise, the fear and the expectation of the new-comer. The other sees what is to him a wonderful model of all that is American.

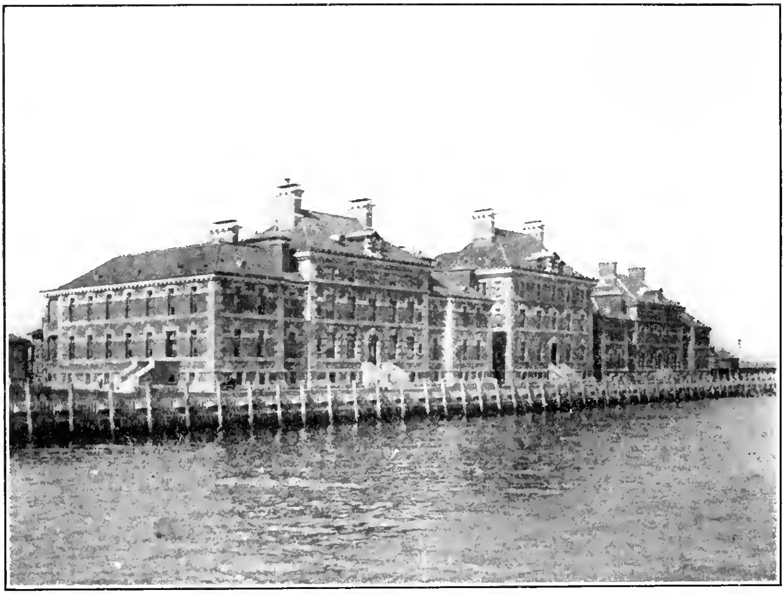


MAIN IMMIGRATION BUILDING.

It is a busy island. Yet in all the rushing hurry and seeming confusion of a full day, in all the babel of language, the excitement and fright and wonder of the thousands of newly-landed, and in all the manifold and endless details that make up the immigration plant, there

is system, silent, watchful, swift, efficient. Five thousand immigrants in a day is no uncommon figure. Five thousand six hundred passed through last Easter Sunday. Five hundred and twenty-five persons are employed on the island exclusive of the score of medical officers and the hundred or more attendants of the Public Health Service.

It is an island crowded full of pathos and tragedy, of startling contrasts and unexpected humor. A burly, laughing giant of a man came



The Immigrant Hospital at Ellis Island.

down the line one afternoon, elated to have reached the land of his life-long hope. The next morning he lay stricken with meningitis and that evening was dead. A young mother was separated from her two-year-old baby because the baby had diphtheria. In a few days the baby died, and the mother went on alone to the father waiting in the west. The reunion of broken families, and the old folks coming to live in the home prepared by the pioneer children, constantly afford views of human nature unmasked and unrestrained.

All races and conditions of men come together here and adjust themselves more or less amicably to each other. Children with no common bond of race, language or religion, play together perhaps more happily for that very reason. Some have been here for months. In the New York room, a Flemish couple have waited seven long months for a little girl who is still sick in the hospital. Every morning on his rounds they ask the doctor how soon she can come to them, and thrice a week they visit her bedside. Perhaps by now their long waiting is

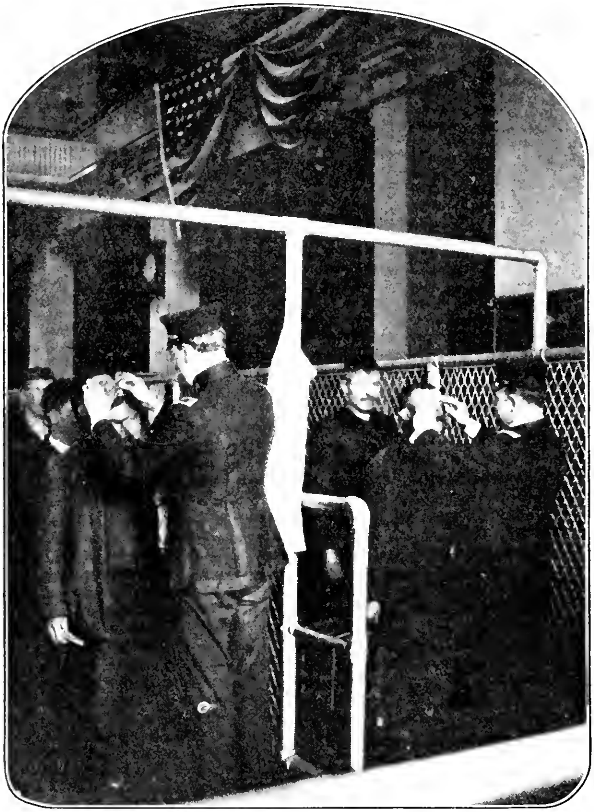
finished, and she has gone on with them happily to the new home in America.

America is the land of the alien, and even now his mark is plain on all our institutions. But while the principal increase in population has been by immigration, the character of that immigration has changed markedly in the past thirty years. Previous to 1883, western and northern Europe sent a stalwart stock, 95 per cent. of all who came. They sought new homes and were settlers. Scandinavians, Danes, Dutch, Germans, French, Swiss and the English islanders, they were the best of Europe's blood. They were industrious, patriotic and far-sighted. They were productive and constructive workers. Where nothing had been, they planted, and mined, and built, and toiled with their hands, while yet finding time to educate their children and train them to love the new mother-country and appreciate the blessings she furnished.

But for three decades the immigrant tide has flowed more and more from eastern and southern Europe. The others still come, but they are far outnumbered by the Jews, Slavs, the Balkan and Austrian

A Polish Mother holding her Baby up to see the Doctor.

races, and those from the Mediterranean countries. In contrast with the earlier immigration, these peoples are less inclined to transplant their homes and affections. They come to make what they can in a few years of arduous unremitting labor, and then return to their homes to spend it in comparative comfort and ease. It has been well



EXAMINING EYES ON THE LINE AT ELLIS ISLAND.

said that America is their workshop, Europe their home. Thirty per cent. of them return to their former homes.

As a class, they contribute little of lasting value but the work of their hands for which they are well paid. And from what they earn they send home no small part. In 1907 they sent $275,000.000 out of the country. True, this money was earned, but its greater value in investment and development was lost. In contrast to their predecessors, the immigrants since 1883 tend to form a floating population. They do not amalgamate. They are here in no small degree for what they can get. It is not always true that they come to supply a real demand. The periodical advertisement of a national demand for cheap labor does not spring from a true economic need, even though the influx of cheap labor might put more money in the employer's pocket.

Such is the type of the newer immigration, and its changing and deteriorating character makes restriction justifiable and necessary. No one can stand at Ellis Island and see the physical and mental wrecks

who are stopped there, or realize that if the bars were lowered ever so little the infirm and mentally unsound would come literally in hordes, without becoming a firm believer in restriction and admission of only the best. The average citizen does not realize the enormous numbers of mentally disordered and morally delinquent persons in the United States nor to how great an extent these classes are recruited from aliens, and their children. Restriction is vitally necessary if our truly American ideals and institutions are to persist, and if our inherited stock of good American manhood is not to be depreciated.

This restriction can be made operative at various points, but the key to the whole situation is the medical requirement. No alien is desirable as an immigrant if he be mentally or physically unsound, while, on the other hand, mental and physical health in the wide sense carries with it moral, social and economic fitness. The present United States immigration law (legislation of 1907) is very definite in its statement of medical requirements for admission. The law divides physically and mentally defective aliens into three classes. Class A includes those whose exclusion is mandatory under the law because of a specified defect or disease. In this class are idiots, imbeciles, epileptics, the feeble-minded, insane and those subject to tuberculosis, or a dangerous or loathsome contagious disease. When a medical diagnosis has been made

Russian Girls.

of these conditions, that person is automatically excluded. In Class B are conditions which are not mentioned in Class A, but which make the person affected liable to become a public charge or affect his ability to earn a living. Class C includes defective and diseased conditions not included under A or B but which must nevertheless be certified for the information of the immigration officials.

The medical inspection of all immigrant aliens is performed by officers of the United States Public Health Service. This service dates from an act of congress in

A Russian Jewish Boy, just landed.

A Chinese Girl in the Dentition Quarters.

1798 creating the original Marine Hospital Service, which conducted hospitals at all large ports and inland waterway cities for seamen of the American merchant marine. The duties of the service have since been enlarged to include all features of national health protection. Its officers rank equal with those of the army and navy medical corps, and are found in all parts of the world pursuing their investigations and carrying out measures to protect the public health of the United States. The medical inspection of immigrants is not the least important of their functions. The Bureau of Immigration is under the

Department of Commerce and Labor, while the Public Health Service is under the direction of the Secretary of the Treasury.

There are 82 immigration stations embracing the entire coastline and frontiers of the United States as well as the entry of aliens into the Philippines, Porto Rico and Hawaii. During the fiscal year of 1911, the total number of immigrants examined was 1,093,809. Of these 27,412 were certified for some mental or physical defect. By far the most important point of entry is Ellis Island, where 749,642 aliens were examined. Nearly 17,000 medical certificates were issued here, and more than 5,000 of these were deported.

The Ellis Island station of the Public Health Service has 25 medical officers attached, including 6 specially trained in the diagnosis and observation of mental disorders. Their work is divided into three sections, the boarding division, the hospital and the line. The boarding division has its offices at Battery Park, N. Y. By means of a fast and powerful cutter, *The Immigrant,* these men meet all incoming liners as they leave the New York Quarantine Station and start up the bay. Their inspection is limited to aliens in the first and second cabins. Such as require a more careful and detailed examination are sent to Ellis Island. The others are discharged at the dock, after having passed the additional inspection of the Department of Commerce and Labor. At the dock, all third and fourth class aliens are transferred to barges, carrying about 700 each, and taken to Ellis Island.

Ellis Island lies close to the Statue of Liberty on Bedloe's Island, about a mile from Battery Park. It is the most commanding location in New York Harbor. It consists of one small natural island and two additional artificial ones, connected with the first by a covered passageway across the intervening strip of water. On the first island is the main immigration station. The other two are occupied by the hospital division of the medical service. On one of these is the general hospital and on the further one the contagious hospital, consisting of separate pavilions, connected with open covered passageways. Each hospital can accommodate close to 200 patients at once, and is usually fairly full. The service is limited strictly to aliens, and the expense of each immigrant receiving hospital care is charged to the steamship company which brought him. This hospital is excellently conducted and every method of most approved diagnostic, surgical and medical technique is practised. A rare variety of diseases is seen. Patients literally from the farthest corners of the earth come together here. Rare tropical diseases, unusual internal disorders, strange skin lesions, as well as the more frequent cases of a busy general city hospital present themselves. The variety of contagious diseases is unusual and extreme diagnostic skill is required of the physicians in charge. In the fiscal year 1911, over 6,000 cases were treated in the hospital, exclusive

THE MATRON AND SOME OF HER CHARGES ON THE ROOF.

of 720 cases transferred to the Quarantine Hospital at the Harbor entrance before the completion of the present contagious hospital on Ellis Island.

The third division of the medical inspection is "the line" or primary inspection. This is the part that the visitor to the island sees, and has been often described. Suffice it to say that as the immigrants leave the barges they pass in single file before the medical officers who pick out all who present evidence of any mental or physical defect. They are turned aside into the medical examining rooms for more careful observation. Each defect or disease receives a medical certificate signed by three physicians, which places the bearer in one of the three classes already mentioned. Those who require immediate medical or surgical care for any reason are transferred to the hospital, as are also certain cases in which longer observation and more detailed examination are necessary for diagnosis. Examples of this are tuberculosis, parasitic scalp diseases, mental disorders and trachoma.

Having been certified or passed clear in the medical division, the immigrant goes together with those from the barge who have not been turned aside, to the upper or registry floor, for the inspection of the immigration authorities. These inspectors ask the same questions that the immigrant was required to answer when the ship's manifest was filled out before embarkation. This covers such information as name, age, destination, race, nativity, last residence, occupation, condition of health, nearest relative or friend in the old country, who paid his pas-

sage, whether in United States before, whether ever in prison, whether a polygamist or anarchist, whether coming under any contract labor scheme, and personal marks of identification such as height, and color of eyes and hair. Any discrepancies in the answers are noted. The immigrant is also required to show what money he has. All who do not meet these questions satisfactorily or who hold medical certificates of classes A or B, are held for a rigid examination before a Board of Special Inquiry, which decides whether or not they shall be admitted. Each of these boards consists of three members, the decision of two members being final. The hearings of the boards are private, but a complete copy of the proceedings is made and filed in Washington.

Those who are to be deported are held on the island until the vessel on which they came is ready for its return voyage. In the event of deportation being ordered, the alien may appeal from the decision of the board to the commissioner of the port, from him to the commissioner-general of immigration, and then to the Secretary of Commerce and Labor.

Those immigrants who have passed satisfactorily and are bound for New York City are sent to the "New York room" to await friends or responsible parties who come for them. This is one of the most dramatic and thrilling spots on the island, for it is the reunion place of friends, relatives and lovers. The Irish girl who came two years ago meets the sister and the old mother. The one is pale, nervous, and clad in New York garb; the others have never seen the ocean until their

THEIR FIRST PHOTOGRAPH.

good ship sailed, and their brilliant cheeks and country dress are in keeping with their dense ignorance and shyness. They know the price of shoes and what spuds are worth at market, but it is beyond them to recall the date of their birthday, or what the present month may be.

Those immigrants who are destined for points other than New York City are sent to the railroad room. Here they change their money for United States coin, and buy their railroad tickets under careful supervision. Their baggage is checked, they have a telegraph, cable and post office of

A GENUINE HAREM SKIRT.

Photograph, taken at Ellis Island, of a woman from Hindustan.

A SERVIAN WOMAN.

their own, and may buy lunches whose contents are exhibited to all in glass cases. Special agents see that each one buys a lunch proportioned to the size of his family and the length of his journey. Cigars, cakes and fruits are also to be had. One day a stolid and emotionless Slavish woman opened her cardboard lunch box at the bottom and extraced a piece of bologna cut on the bias, smelled it carefully from different sides, licked it, finally tasted it, and then broke into a flood of smiles as she pressed it forcibly into the mouth of her equally stolid two-year-old baby. And the baby sucked and munched on the new

world dainty in undiscerning pleasure! But the greatest mystery in the lunch box is usually the small round fruit pie. Some carefully raise the crust and extract the contents with a much-used finger. Another whittles it off in slices with a murderous knife a foot in length, while another will carefully eat off all the crust and discard the interior. A bearded Cossack with great care and patience chewed a hole through one corner of a tin of sardines. Then with praiseworthy perseverance, he sucked out the oil! From the railroad room, the immigrants are taken in barges to the depot of the railroad on which their journey is to be made.

Those immigrants who are to be deported, or who for any reason must be kept on the island some time, are placed in the detention quarters. These are not open to visitors. Tiers of beds are provided, accommodating 1,800 persons, but often this number is exceeded by 500. These quarters are among the most interesting points on the island. The women and children of all races and tongues are in one large room, and the men in another. In mild weather they are all sent on to the fine broad roof of the building. Not long ago a Danish woman who could speak no English and whose baby was in the hospital with diphtheria, became a second mother to a coal-black pickaninny, who had come up from Trinidad on a coffee-ship and whose mother was also in the hospital. Again race wars occur among the children, and Turks and Armenians will battle ferociously with Italians. Mention should be made of the large immigrant dining-room which seats 1,100, where the missionary societies hold a polyglot Christmas entertainment each year.

But the observer at Ellis Island sees only the immigrant stream flowing in. He does not see what results when it has been distributed over the country. No graver questions are before the American nation to-day than those associated with immigration, and none whose correct solution demands more imperative attention. One of these vital questions which is in special prominence just now, is the relation of immigration to mental disorders. This question concerns New York state more acutely than other states only because New York has the largest number of alien defectives.

In February, 1912, there were 33,311 committed insane cases in New York state institutions. It is estimated that more than 8,000 of these or, roughly, 25 per cent., are aliens, and this is exclusive of those conditions of mental defectiveness listed under idiocy, imbecility and feeblemindedness. In the New York schools there are about 7,000 distinctly feeble-minded children, or about 1 per cent. of the school population. Again this does not include idiots and imbeciles to an equal number, not attending school, nor border-line cases and morally defective children. The total number of feeble-minded children in New

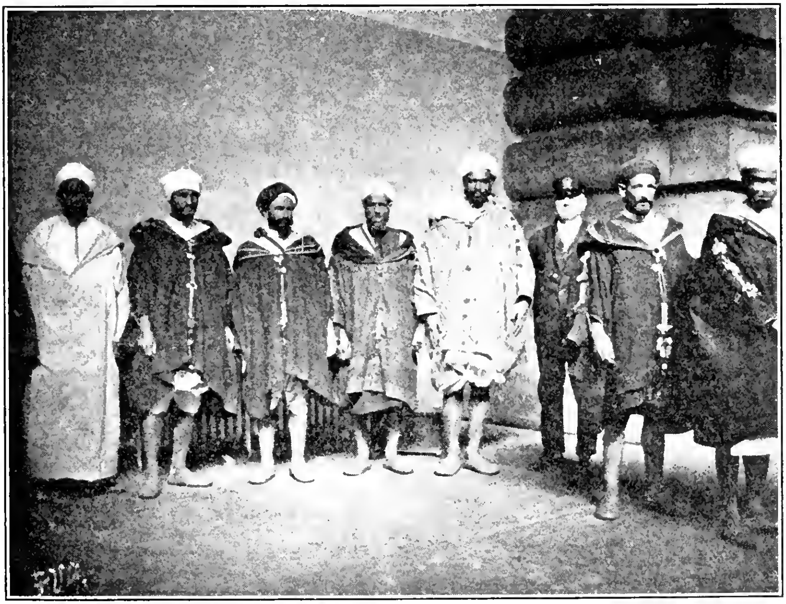
A Pair of African Arabs, awaiting the Medical Examination.

York is about 10,000. According to the figures of the last census, 30 per cent. of the feeble-minded children in the general population throughout the country are the progeny of aliens or naturalized citizens. Thus the presence of 3,000 of New York's feeble-minded children can safely be laid to immigration. These figures show the extreme necessity of careful medical inspection of immigrants. But there are many complicating factors. It is very difficult to recognize many types of insanity. It is almost impossible to detect feeble-mindedness in infants and young children. Yet in spite of this, the medical officers at Ellis Island are doing thorough and effective work, and do not at all deserve the ignorant criticism of those unfamiliar with the difficulties of that work.

A point where criticism is unfortunately valid is in the matter of the deportation of aliens who within three years after landing show themselves subject to any of those conditions which the law excludes, or who become public charges from any cause, said condition or cause

having existed prior to landing. If the present entrance inspection was reinforced by a determined administration of these deportation laws, and if all cases whose exclusion the law makes mandatory, and which are now certified by the medical officers, were actually excluded, there would be little cause for complaint. But such a condition does not obtain. The medical officers have nothing whatever to do in passing judgment on whether an immigrant shall be admitted or not. Their province alone is to certify to his physical and mental status. The question of admission, as well as of deportation, rests with the officials of the Department of Commerce and Labor.

Much easier is the control of organic physical diseases, as, for example, hookworm infection. A survey of the prevalence of hookworm disease throughout the world, made by the Rockefeller Sanitary Commission, shows that this infection belts the world in a zone 66° wide with the equator near its middle, and that practically every country in this zone is heavily infected. It is evident how grave a danger lurks in immigration from any country where the hookworm is prevalent. Among the worst afflicted countries is India, where it is estimated that from 60 to 80 per cent. of the population of 300,000,000 harbor this parasite. This leads peculiar interest to the movement of Hindu coolies into the United States in the last few years. A shipload of these coolies landing recently in San Francisco were found by the health authorities of that port to have 90 per cent. infected with hookworm.



Berbers from Algeria, coming to fill an Engagement at a New York Theater.

An Italian Family.

Every colony and camp of Hindus in California to-day is a dangerous source of infection to all the country around. A rigid quarantine has been established against further importation of this class of aliens.

There are numerous other questions besides those which have been touched on here. Immigration presents one of the most serious problems facing this country. Ellis Island is where the needs and dangers of the country in this regard are focused. Its ever-changing stream of humanity furnishes a fascinating realm for the student of human nature, as well as for study of the great question of economics and eugenics which are involved.

SOME IMPRESSIONS OF THE FLORA OF GUIANA AND TRINIDAD

By Professor DOUGLASS HOUGHTON CAMPBELL

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TO most botanists in America a visit to the tropics is supposed to be a difficult and expensive undertaking, involving much special preparation and also a good many risks. The fact is, a trip to the West Indies is a very simple matter, and even a few weeks are sufficient to give one an excellent idea of the main features of a most interesting and characteristic tropical flora, and is no more expensive than a journey of equal duration in Europe. If one extends the trip to include the Isthmus of Panama and Trinidad, one sees to great advantage the rich and beautiful flora characteristic of equatorial South America, one of the most individual floral regions of the world.

There are various ways of reaching the West Indies and northern South America, especially since the great development of the fruit industry, which employs many vessels plying constantly between the different ports of the Atlantic and Gulf States, and various ports of the West Indies and Central America. In addition, the Royal Mail (English), and the Dutch Royal Mail have steamers plying between New York and Europe *via* the West Indies and South America.

It may be mentioned, also, that a trip to the tropics in summer is not at all the trying experience that many persons suppose. Of course, it is hot, and in most parts of the West Indies rainy in summer; but the heat never equals that sometimes experienced along our own Atlantic coast, and, moreover, there are none of the sudden changes that are so trying. The same clothing that is suitable for hot weather in New York will be found quite appropriate for the tropics.

With the great improvements in sanitation of late years there is very little danger from the fevers which formerly gave this region such a bad name. With ordinary precautions, there need be little apprehension on this score.

Having a few weeks at his disposal, the writer decided to go to Europe *via* the West Indies, instead of by the shorter, but infinitely less interesting, route across the northern Atlantic.

Wishing to see something of the South American mainland, it was decided to go first to Paramaribo, the capital of Surinam (Dutch Guiana), as it is possible to go there directly from New York, in about

ten days. From Paramaribo it is two or three days to Trinidad, where one can catch the Royal Mail for England.

The route from New York to the Guianas lies to the eastward of the larger West Indian Islands—the Greater Antilles—and passes close to the line of smaller islands, the Lesser Antilles. These are for the most part extremely mountainous, and the larger ones, like Dominica and Martinique, are exceedingly beautiful, and are also said to be most interesting botanically. Dominica, especially, with mountains rising some 5,000 feet above the sea, and evidently presenting great variety of conditions, made one wish that the ship would stop long enough to enable one to explore the luxuriant forest clothing the steep mountains to their summits.

Passing close to Martinique the sinister bulk of Mt. Pelée dominated the view, and the ruins of St. Pierre could be plainly seen—now after ten years largely overgrown by the rank tropical vegetation which is rapidly covering up the evidences of the great catastrophe.

No stop was made until Barbados was reached. This densely populated island is mainly devoted to the cultivation of sugar, and there is very little forest left. Moreover, unlike most of the West Indian islands, the elevations are comparatively slight, and the conditions much more uniform than in the other islands. To a newcomer in the tropics, however, no doubt the many striking cultivated plants will be a novelty. Some of the showiest flowering trees and shrubs, like the gorgeous flamboyant *Poinciana regia* and the beautiful frangipani (Plumiera), come to special perfection in the gardens of Barbados. Here one sees also the very striking mixture of races found in the West Indies—negroes form a large majority of the population, but there are many East Indian coolies; and a considerable number of Chinese. The white population is insignificant compared with the various colored races.

The next stop was made at Georgetown, the capital of British Guiana, or Demerara. The ship remained all day in port, and there was an opportunity to go on shore and visit the pretty botanical gardens. The town itself is attractively laid out, and the gardens full of luxuriant tropical growths testify to the thoroughly tropical climate. Fine avenues of tall palms are a striking feature of the town. These were apparently mostly the royal palm (*Oreodoxa regia*), but it is not always easy to distinguish this from the even finer cabbage palm (*O. oleracea*).

The botanical garden is really an attractive park rather than a scientifically laid out botanical garden. It contains, however, many fine specimens of palms and other tropical plants which will interest the botanist. Perhaps the finest features of the garden are the extensive

lily ponds, where one can see growing with wonderful luxuriance the *Victoria regia* and other tropical water lilies. A pond full of lotus (Nelumbo) with thousands of white, pink and crimson flowers, was a truly magnificent sight.

Unfortunately, practically none of the original forest has been left in the immediate vicinity of the city, and one must go a long way before one can see the untouched native vegetation.

A day's sail from Demerara brings the traveler to Paramaribo, the capital of Surinam (Dutch Guiana). Paramaribo is a picturesque town, the high-gabled houses with their quaint stoops and doorways looking curiously alien under the shade of great mahogany trees and royal palms. Some of the houses, the former residences of wealthy Dutch merchants, are fine examples of their kind, and recall the flourishing days of the seventeenth and eighteenth centuries when the trade of Surinam was much more important than it is to-day.

The streets are lined with rows of palms and other tropical trees, among which the finest are the gigantic old mahogany trees.

The botanical gardens lie on the edge of the town, and are devoted principally to the cultivation of various economic plants—cocoa, rubber of various kinds, oranges, mangoes, bananas, coffee—and other less known tropical products.

To the botanist, undoubtedly the most interesting feature of the garden is a tract of untouched forest immediately adjoining it. This is an excellent sample of the predominant forest of the region. The greater part of this forest is more or less submerged for much of the time, but at intervals in this swamp are low ridges of more sandy soil, and in these drier areas grow the largest trees, two of which, the silk-cotton (*Ceiba pentandra*) and the sand-box (*Hura crepitans*) are veritable giants. The trunks and branches of these great trees were covered with numerous epiphytes, among which the Bromeliaceæ take first place. Several species of Tillandsia, including the familiar *T. usneoides,* the "Spanish moss" of our own Gulf States, were conspicuous. Clinging to the giant trunks, or festooned from tree to tree, were many lianas, some of great size. Convolvulaceæ, Bignoniaceæ, and especially the giant scandent Aroids—Philodendron, Monstera, Syngonium, and others—were noticeable among the tangle of creepers.

An undergrowth of dwarf palms and many showy Scitamineæ, especially species of Canna and Heliconia, gave the finishing touch to this truly tropical picture.

Almost no ferns were to be seen, and bryophytes—especially liverworts—were few and inconspicuous. Of the latter, only a few small leafy Jungermanniaceæ, growing on the tree trunks, were noted. In the town, and about the garden, a few epiphytic ferns were common.

Fig. 1. Forest adjoining the Botanical Garden, Paramaribo.

These included species of Polypodium and Vittaria. This poverty of the fern flora is quite in accord with the account given by Spruce of the forests of the lower Amazon.

Through the kindness of Dr. Cramer, the director of agriculture, and other members of the scientific staff, an opportunity was afforded of visiting a number of the most characteristic regions within reach of Paramaribo, and an excellent idea was thus obtained of the more salient features of the flora of this region. Excursions were made up the Surinam River and some of its tributaries, as well as to one of the characteristic "savannas" occasionally met with in lower Surinam.

Except in the immediate vicinity of Paramaribo there are no roads, and communication (except for one line of railway) is almost entirely by means of boats, which ply along the rivers, creeks and canals with which the whole country is intersected.

Owing to the flatness of the country, the tide extends for a long way up the larger streams, and these rivers are everywhere bordered by an impenetrable mangrove swamp, in the lower reaches of the rivers composed almost exclusively of *Rhizophora mangle*, but higher up, where the salinity of the water is less, the Rhizophora is gradually replaced by *Avicennia nitida*, which sometimes becomes a large tree, whose aerial roots often develop from the upper branches and reach an enormous length. Back of the mangrove belt there sometimes occur slightly elevated ridges upon which the largest trees grow.

Nearly all of the cultivated land in lower Surinam has been reclaimed by building dykes, and the old sluice gates, two or three hundred years old, in some cases, are a characteristic feature in the landscape.

Two of the large plantations were visited, and an opportunity was thus given of seeing the methods in use in the cultivation of the various tropical productions of Surinam—cocoa, coffee, oranges, bananas, cassava, rubber, etc. On one estate there were extensive plantations of Para rubber (*Hevea braziliensis*), and the somewhat primitive, but apparently satisfactory, preparation of the sheets of merchantable rubber could be seen in all stages.

In these large plantations the canals intersecting them in various directions were the principal means of communication, although along the dykes were usually footpaths, which were not always, however, in the best of condition—especially when the clay was slippery after one of the frequently recurring showers.

As the salinity of the water decreases in the upper reaches of the rivers, the mangrove formation is gradually replaced by other trees and shrubs. Several Leguminosæ, especially species of Inga, are common, and great numbers of a big Arum (*Montrichardia arborescens*),

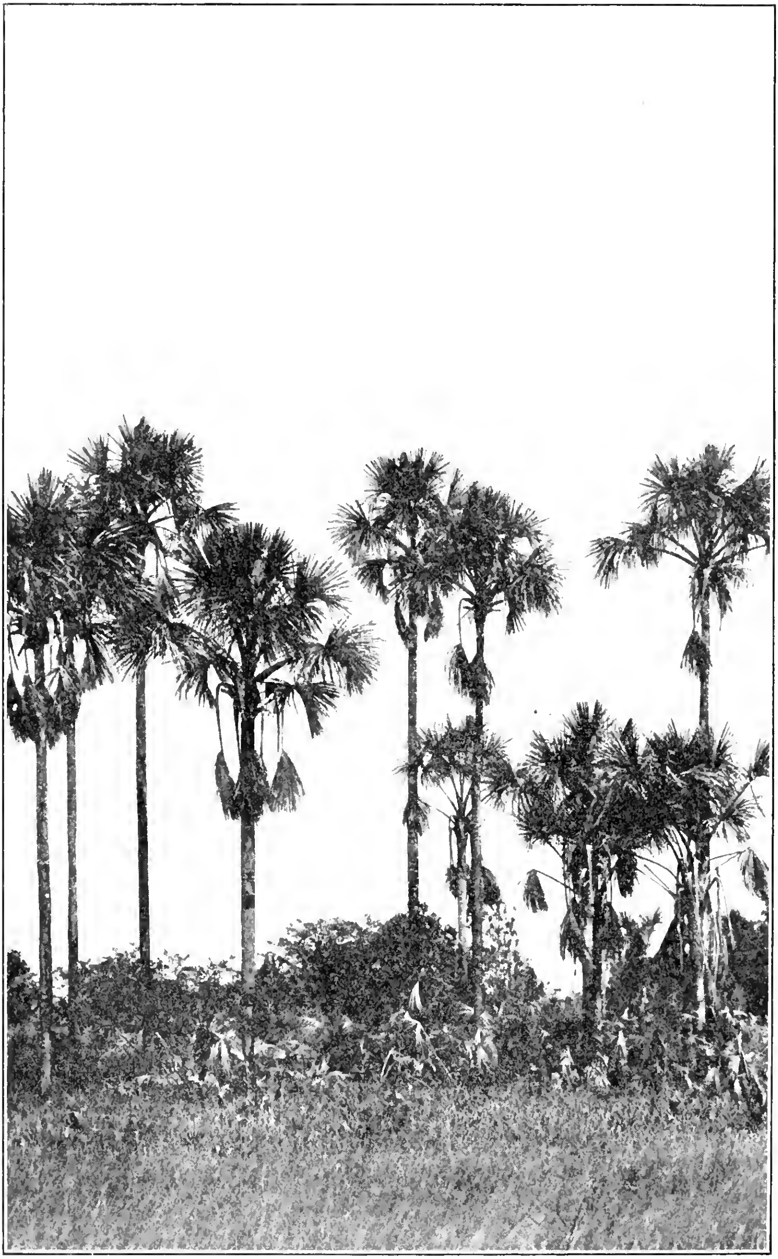

FIG. 2. EDGE OF A FOREST ON THE SURINAM RIVER.
The tall palms are *Euterpe oleracea*.

a constant feature of the brackish and fresh-water swamps, form dense thickets, the crowded bare stems forming a close palisade fringing the margins of the rivers. With the decrease in the salinity of the water, also, palms of various kinds begin to appear, and these constitute quite the most striking growths of the forest along the fresh-water streams. They occur in immense numbers and great variety, and some of them are extremely beautiful. First in abundance—and perhaps also in beauty—is *Euterpe oleracea,* whose slender stems and graceful crowns of feathery leaves occur by thousands. Other conspicuous palms are species of Attalea, Maximiliana, Astrocaryum, Manicaria, and others. Several small palms, especially species of Bactris, occur in great numbers as an undergrowth in these swampy forests. Another striking palm is a Desmoncos, whose flexible thorny stems and graceful pinnate leaves, armed with savage hooked thorns, were festooned from tree to tree. This palm closely resembles the rattan palms of the old world. Its large clusters of scarlet berries were conspicuous, and often attracted attention as the boat skirted the dense mass of vegetation along the shore.

In addition to the many native palms, a number of exotic species are cultivated. Among these are the African oil-palm (*Elæis guinensis*), the royal palm and the cocoanut. The last, however, does not thrive, due perhaps to the excessive moisture in the soil.

A very common and wide-spread member of the tropical American flora is the genus Cecropia, whose slender branches and big palmate leaves occur everywhere.

As might be expected, the development of climbing plants is extremely luxuriant in these wet forests, and in many cases the lower trees and bushes were almost smothered by the dense curtain of creepers of various kinds with which they were draped. These creepers belong to very diverse families—Convolvulaceæ, Passifloraceæ, Apocynaceæ, Melastomaceæ, etc., and many of them have flowers of extraordinary beauty, which add much to the attractiveness of these rich forests.

Very different from the wet forests are the "savannas," one of which was visited. These savannas are in many respects like the moorlands of more northern regions. The soil of the one visited was a coarse sand covered with a sparse growth of coarse grasses and sedges, with scattered clumps of low shrubs, among which were growing a number of orchids. Only one of these, a Catasetum with large greenish flowers, was found in bloom. There were here and there shallow pools, in which were growing tiny yellow Utricularias and minute Eriocaulaceæ and Xyridaceæ. Under the clumps of shrubs were noticed small patches of Sphagnum, and a small species of Drosera closely resembling in form the common D. rotundifolia of

FIG. 3. GROVE OF MAURITIA PALMS IN A SAVANNA, SURINAM.

northern bogs. A very beautiful blue bell-gentian was common. This does not belong to the genus Gentiana, but to a related one, Chilonanthus. A few ferns were noted, among them the ubiquitous *Pteris aquilina.* The shrubby plants belonged mostly to the distinctly tropical families Malpighiaceæ, Melastomaceæ, Rubiaceæ and others.

Among the showiest flowers collected near the savanna, but at the margin of the forest, was an extremely beautiful rubiaceous shrub, which was not determined. Its large rose-colored bell-shaped flowers were produced in great profusion, and were most ornamental. A large purple Clitoria, an extremely showy papilionaceous creeper, was also common.

Much the most striking plant of the savanna, however, is a magnificent fan-palm, *Mauritia flexuosa,* which occurs in groves of considerable size, making a very imposing sight.

Adjoining the savanna was a fairly dense forest, with comparatively dry soil, although there were numerous clear streams, deep amber brown in color, and in places it was decidedly boggy. As in all the forests, the palms formed the most conspicuous feature of the undergrowth. Ferns and liverworts were more abundant than in the forests near Paramaribo, and at the base of some of the trees a small Trichomanes was not uncommon, the only Hymenophyllaceæ that were collected. An interesting tree of this forest was the "Balata," a species of Mimusops which yields rubber of fair quality, which is collected in considerable quantities by the natives. There also occurs a species of Hevea, which, however, is much inferior in its product to the Para rubber tree. A not uncommon plant of this forest—and also seen repeatedly elsewhere—is *Ravenala Guianensis,* much resembling the well-known "traveller's palm," *R. Madagascariensis.* There was also the usual profusion of other Scitamineæ.

The flora of Surinam is remarkable for the abundance of showy flowers—not a usual condition of things in the wet tropics. Among the most conspicuous of these are many splendid climbing plants—especially various Bignoniaceæ, Apocynaceæ, Convolvulaceæ and Passifloraceæ. Some of these, like the golden yellow Allamandas and crimson and rose-colored passion flowers, were truly magnificent. There were also many showy shrubs, especially various Rubiaceæ, Malpighiaceæ and Melastomaceæ.

Of the herbaceous plants probably the showiest are the very abundant *Heliconias.* These look much like Cannas—or the larger ones like bananas—and their scarlet and yellow inflorescences are extremely brilliant. There were also great masses of red and yellow Cannas, and other showy Scitamineæ—*e. g.*, Costus, Maranta, Thalia, etc. These brilliant flowers occurred in great masses along the margins of the forest, and the railway embankment was a veritable botanical garden.

Associated with these distinctly tropical plants were a number of more familiar aspect. The well-known red and yellow *Asclepias curassavica* was extremely common, and several species of Verbenaceæ and Compositæ were quite like northern forms.

Next to the palms, perhaps the most characteristic plants are the Araceæ, which occur in great number and variety. Besides those already referred to, perhaps the most noticeable were species of Caladium, whose brightly colored leaves were a common feature of low ground everywhere.

Of the epiphytic plants, the Bromeliaceæ take first place. There are also many species which grow upon the ground and closely resemble pineapples in their general appearance.

Surinam is not specially rich in orchids, and of these very few were in flower when the writer visited the country. The most interesting form encountered was a species of Catasetum (*C. fuliginosum*), already referred to.

As might be expected, aquatic plants are very numerous. Owing to an abnormally dry season prevailing during the early part of the year which dried up many bodies of water, comparatively few of these were in flower. Azolla was abundant in the ditches and canals, and also a species of Salvinia. The leaves of water lilies were abundant, but no flowers were seen. About the margins of ponds were sometimes seen the big white flowers of *Hymenocallis obtusata,* looking like white lilies.

Although Trinidad is reckoned with the West Indies, its flora is very different from that of the Antilles, and is essentially South American in type. Trinidad is separated from the mainland of Venezuela by only a few miles and the plants are largely the same as those in the adjoining regions of Venezuela and have much in common with those of the Guianas.

During a stay of two weeks the writer visited only the northern part of the island. This is, however, the most interesting portion of Trinidad, as not only are the highest mountains here, but there is also a fine development of lowland forest, and a savanna formation much like that seen in Surinam.

Port of Spain is perhaps the most attractive of the West Indian towns, and offers much of interest to the botanist—both in the town itself and in the environs. The botanical garden in Trinidad is the best in the West Indies, and in addition to the many fine examples of tropical plants cultivated in the garden there is adjoining it a considerable tract of practically untouched jungle, which is easily accessible and is full of interest to the visiting botanist. The garden is now under the direction of Mr. W. Freeman, to whom the writer is under obligations for much kind assistance during his stay in Trinidad.

Close to the old botanical garden is the more recently laid out

agricultural experiment station, where are to be seen many varieties of the principal tropical fruits, especially oranges and mangoes. The latter are especially fine in Trinidad.

Among the most striking features of the botanical garden are the palms, of which there are many magnificent specimens, both native and exotic. In the town itself palms are planted in great numbers, especially the stately cabbage palm "palmiste" of the French creoles, probably the finest of all palms. It is a common sight to see clumps of epiphytic orchids attached to the trunks of trees in the gardens of Port of Spain. These are said to be very beautiful during the early winter, but in July only a very few were in blossom.

In Port of Spain there are magnificent trees in the parks and gardens and along the roads. These are often of enormous size, and their branches are frequently covered with epiphytes of various kinds, among which the most conspicuous are the Bromeliads, and the curious *Rhipsalis Cassytha,* a member of the Cactaceæ, but very different from most of the family. This plant grows in immense pendent masses, sometimes ten feet or more in length, and is exceedingly common in Trinidad. Of the numerous large trees, the silk-cotton (Ceiba), the West Indian cedar (*Cedrela odorata*), and the sand-box (*Hura crepitans*) were the commonest of the native species; but mahogany trees of large size, and gigantic specimens of *Pithecolobium Saman,* are frequently seen. A very curious native tree, *Couropita guianensis,* is sometimes seen planted. This produces many short branches from the main trunk, upon which the large red flowers are borne in great numbers. These are followed by enormous globular fruits of such size as to fairly entitle the tree to its popular name, "cannon-ball" tree. Space will not permit of any further enumeration of the beautiful and curious plants with which the gardens are filled.

Much of the country about Port of Spain is still but little disturbed, and even where it has been cleared, the neglected land soon reverts to jungle. The wetter lowlands abound in palms, Aroids, Scitamineæ, etc., much the same types that occur in the Guiana forest. The drier hillsides, however, show a good many forms different from those of the lower levels. A very common palm of the dry hillsides is *Acrocomia sclerocarpa,* a species common to the Antilles also, and very common in Jamaica. A very showy shrub of this region is a rubiaceous plant, *Warscewiczia coccinea.* In this plant, as in the related Mussaenda of the eastern tropics, one of the calyx lobes is much enlarged and petal-like in color and texture. In Mussaenda this is white, but in Warscewiczia it is a vivid carmine red, and the whole inflorescence strongly suggests the familiar poinsettia—indeed the plant is locally known as wild poinsettia.

Ferns are much commoner in Trinidad than in Guiana, although

at the lower levels they are not especially notable. Two species of Schizæaceæ were common near Port of Spain—a Lygodium sp. and *Anemia phyllitidis*.

A visit to a small waterfall a few miles away yielded a considerable number of ferns, including some small Hymenophyllaceæ and a Danœa, and also several interesting liverworts. In the botanical garden were also found two interesting liverworts, a large Riccia and a Notothylas (?).

While driving to the waterfall a fine white arum (*Spathiphyllum cannæfolium*) was seen in great numbers along the river, and the trail to the falls led through a fine forest with tall trees and a luxuriant undergrowth of large ferns, some of which were small tree-ferns. There were also many Aroids, some of great size—Montrichardia sp., Philodendron, Anthurium, etc. Some very showy Bromeliads, with fine scarlet bracts, were common as epiphytes, and also a good many orchids; but some of the latter were in flower. These, with the gorgeous Warsczewiczia and masses of the fine *Heliconia Bihæ*, made a magnificent picture of tropical vegetation in its most luxuriant aspect.

Small tree ferns (species of Alsophila and Hemitelia) were fairly abundant, and several young specimens of a Danæa were found on a wet bank, where there was also found a luxuriant growth of several interesting liverworts. The latter included species of Aneura, Metzgeria, Symphyogyna (?), Fossombronia and Dumortiera.

In company with Mr. Freeman, assistant director of agriculture, a very interesting excursion was made to the Aripa savanna, some 25 miles from Port of Spain. This savanna was in many respects like the one visited in Surinam, but the vegetation was more luxuriant. There were similar groves of Mauritia, but even a finer species (*M. setigera*). A number of beautiful ground orchids were found in flower, and a small Drosera, different from that found in Surinam, was common. Tiny Utricularias with yellow and purple flowers were abundant, and as in the Surinam savannas, there were clumps of low bushes, largely Melastomaceæ and Malpighiaceæ, in the shelter of which was found a very interesting fern, *Schizæa pennula*, as well as several other ferns. Two species of *Lycopodium*, *L. cernuum* and *L. Carolinianum*, were common.

The forest adjoining the savanna was very beautiful, with fine palms—Euterpe, Bactris, Attalea, Maximiliana, and others. A Commelynaceous plant with yellow flowers was very abundant (the same species was also seen in Surinam) and there were the usual abundant epiphytic orchids and Bromeliads, as well as a number of small Hymenophyllaceæ.

In these woods were many specimens of a Clusia, growing first as an epiphyte, and sending down aerial roots, which finally completely strangle the tree upon which the Clusia has fastened itself. These

parasitic trees, with their glossy magnolia-like leaves are extremely handsome, and much resemble in general appearance the species of Ficus, so common in the eastern tropics, which have the same habit of strangling the tree which gives them support.

Trinidad has no very lofty mountains, the highest peak, Tucuche, being very little over 3,000 feet. The most interesting excursion made was to this mountain. In company with Mr. Freeman, Mr. Urich, the government entomologist, and Mr. Chandler, an English botanist visiting Trinidad, the writer made the ascent of the mountain which offers no difficulties, and many interesting plants not found in the lower country were seen.

The route at first lay through extensive cocoa plantations, which occupy much of the lower forest lands in Trinidad. Along the margins of the streams the showy Aroid, *Spathiphyllum cannæfolium,* made a fine show, and another conspicuous and interesting plant was the curious *Cyclanthus bipartitus*, a member of the small family Cyclanthaceæ, whose systematic position is something of a puzzle to the systematist.

Lygodium sp. and *Anemia phyllitidis*, characteristic ferns of the lower country, were abundant, and a number of other ferns were noted as well as a few liverworts. These, however, are much better developed at higher elevations where there are a number of species of tree ferns belonging to the genera Alsophila, Cyathea and Hemitelia. None of these attain large proportions, and neither in the number of species nor in the size of individuals can Trinidad compare with Jamaica.

At an elevation of about 1,500 feet the primitive forest begins—characterized by magnificent tall trees, whose species in most cases could not be determined. The dense undergrowth comprised large ferns, palms, Heliconia, Araceæ of various kinds, and many shrubs and lianas, the whole forming a magnificent example of a wet tropical forest. That it was a "rain forest" we thoroughly appreciated, as we passed through it in a veritable tropical downpour which soon made every little ravine and gulley the bed of a torrent, and much of the time we had to wade through these small cascades when they crossed the trail.

However, although thoroughly drenched, we finally reached the summit where there is a shelter hut in which we were to pass the night. The rain ceased for the time being, and after a change into dry clothes the afternoon was spent exploring the upper part of the mountain.

Among the most noticeable plants of the summit were many Bromeliaceæ, mostly epiphytes, but some of them growing on the ground. The scarlet and yellow bracts of some of these were extremely showy. Several species of palms were abundant, and especially *Geonoma sp.* confined to the higher elevations. One of the most beauti-

ful plants met with was a species of Utricularia, *U. montana,* sometimes seen in cultivation. Unlike most of the genus, this is an epiphyte, and the drooping racemes of big white flowers might very well be mistaken for an orchid.

As is usual at the higher elevations in the tropics, the lower plants are relatively more abundant than at lower elevations. Besides, the tree ferns there were many others, including several Hymenophyllaceæ and two species of Danæa, which were growing abundantly upon the wet banks, and whose large liverwort-like prothallia were found in quantity. The wet banks also yielded a fair number of liverworts, and at the very summit the ubiquitous *Lycopodium cernuum* was abundant. Mosses and lichens also abounded, but no notes were made of the species.

To the botanist visiting this region for the first time, the abundance and variety of the palms will first attract attention. Many of them are exceptionally beautiful, and they often grow in large masses giving a characteristic stamp to the forest vegetation. Palms are a far more conspicuous feature in the South American tropical forest than in any part of the eastern tropics with which the writer is acquainted. The Araceæ, also, are more numerous and varied than in the tropics of the old world, and none of the old-world forms can rival the giant scandent genera, like Philodendron and Monstera, which are so characteristic of the American tropical forests.

Of the numerous Scitamineæ the common Heliconias with their gorgeous inflorescences will first attract attention, and of course the peculiarly American family, Bromeliaceæ, will be of special interest to the European visitor.

The prevalence of showy flowers in Surinam was noteworthy, as this is not a common feature in the wet tropics, a fact frequently commented on by scientific travelers. Whether or not the two go together, it may be mentioned that in Surinam there is also an extraordinary abundance of brilliant butterflies, some of them of wonderful beauty.

In Trinidad the prevalence of showy flowers was much less marked than in Surinam, although it is by no means deficient in striking flowers. As has already been stated, Trinidad in the main features of its flora belongs rather with the continental region of South America than with the other islands of the West Indies.

A GRAIN OF WHEAT[1]

By R. CHODAT

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PEOPLES truly rich are those who cultivate cereals on a large scale. Scores of investigators in all civilized countries devote themselves unceasingly to a problem of great social significance, viz., the increase of the national wealth through progress in agriculture. The least discovery in this field, whatever the political journals may say, is more important for a country than a change of the party in power. For it is the history of discoveries and inventions—in the domain of nature, as well as in the intellectual field—that constitutes the real history of civilizations.

Thus the modern improvements in the industry of milling in connection with better transportation facilities have helped to provide better bread for all classes and have rendered famine impossible in the Europe of to-day.

Is it then any wonder that since the most remote antiquity germinating wheat has been the symbol of mysterious and hidden life, that in their religious ceremonies the ancients attached so much importance to cereals offered on the altar, that our modern artists, putting aside the petty themes of political events, have glorified the beauty and nobility of harvests, the poetry and mystery of sowing, in justly renowned paintings? Roty's admirable sower on the French coins, who symbolizes the value of this idea, shows us the highest art seeking its inspiration at the very source of civilization—the culture of wheat.

I do not wish to overtax your attention or indulge overmuch in scientific pedantry by enumerating to you, together with their botanical characteristics, the different kinds of wheat which have been and are still cultivated. I shall merely give you as much as is essential for my purpose. The most competent botanists in this field agree in recognizing at least three species of wheat:

1. Einkorn (*Triticum monococcum*).
2. Polish wheat (*Triticum polonicum*).
3. Wheat (*Triticum sativum*).

These distinctions are based not only on morphological characters, but also on a character which is accepted on good grounds as usually

[1] Presented before the General Meeting of the Société des Arts, Geneva, Switzerland. Translated from the French by Maude Kellerman.

separating species from varieties, that is, their sterility when crossed among themselves, or their failure to produce fertile offspring. Attempts to cross these types have never given results.

Ordinary wheat may be divided into numerous varieties or subspecies, reciprocally fertile, which are grouped about the following subspecies:

Emmer (*T. dicoccum*).
Spelt (*T. spelta*).
Wheat proper (*T. tenax*).

The first two subspecies differ from the third in that the ear has a fragile rachis and the grains remain covered by glumes which must be removed by a somewhat complicated process, whereas in the third species the grains on ripening fall from the ear the rachis of which is not articulated. I shall give here only what is most essential for the understanding of what is to follow. Now, it is evident that emmer and spelt are inferior to true wheat because of the fragility of the rachis of the ear and because of their enclosed grains. Whenever it is possible wheat is grown instead of emmer or spelt.

Not to prolong the discussion of these classifications, let us say at once that wheat proper is represented in cultivation in various parts of the world by a considerable number of varieties, but it is difficult even for the specialist to distinguish them. One of these varieties, having a non-articulated rachis (*Triticum durum*), the hard wheat of the Mediterranean countries, is so closely related to emmer that the systematic affinity of the wheats with an articulated rachis and those with a non-articulated rachis can not be questioned.[2] Each year, in agricultural experiment stations organized according to the principles of Vilmorin, Rimpau or Svalöf, new races are brought to light and are tested out in suitable soils and climates. I do not wish to tire you by a dry enumeration of all these forms; even had I the time for it I should not be competent to perform this task.

Which of all these varieties of cereals first appeared in cultivation? To this question we may reply that it is certain to-day that emmer was cultivated by the Egyptians from the time of the first dynasty, or about 6,000 years ago. The glumes preserved in the tombs show that the grain was already at that time freed from its envelopes by the use of special machines; it was not simply flailed or tramped out by cattle. Einkorn and emmer have also been found among the débris of the granaries of the lake-dwellers of Switzerland. Hard wheat, which of all the kinds of wheat proper most nearly resembles emmer, has also been cultivated in Egypt since very ancient times. If we regard the

[2] Aaronsohn, Aaron, "Agricultural and Botanical Explorations in Palestine," Bulletin No. 180, United States Department of Agriculture, 1910, Bureau of Plant Industry, 64 pp., 9 pls., 12 text figures.

matter from an evolutionary standpoint, according to which related races, varieties and species had a common origin, we can arrive logically at but one conclusion, namely, that the most ancient wheats were those with a fragile rachis. One arrives at the same conclusion on comparing the cultivated barley, having an articulated rachis, with the wild barley which has a fragile rachis.

The well-preserved emmer glumes in this bottle which I am going to have passed around were found at Abusir in the tomb of the king Newoser-re (Dyn. v. 2400 B.C.). This material was very kindly sent me by the Oriental Society of Berlin.

If, on the other hand, we look to Europe and Asia to see in which countries these ancient cereals are still cultivated, we shall find them in the northern Jura, in the countries of the Basques, the Servians, the Swabians and the Bactrians of Persia. We see that these cereals have maintained themselves only in mountainous countries or among the peoples most remote from the centers of civilization. The cultivation of emmer has long since disappeared from the fertile plains of Egypt, where it was superseded by that of hard wheat.

Knowing, therefore, that the wheats cultivated in most ancient times were those with a fragile rachis, we are confronted by a second question: Where is the home of this type of wheat? In what country did our first parents, our prehistoric ancestors, find this plant, most precious of all plants?

As for the einkorn, we know its home since the botanist Balansa found it in Asia Minor. It is true that Balansa's wild plant differs from the cultivated einkorn in certain characters and it has been named *Triticum monococcum,* var. *ægilipoides.* But it has already been noted that this species is too distinct from wheats to allow it to be considered as their prototype.

For more than a century botanists and historians of civilization have sought for the home of wheat. In vain have all the resources of comparative morphology been employed, as well as those of history and philology. The origin of wheat remains shrouded in mystery. The ancients attributed its introduction into the world of men to some beneficent goddess, thus putting the mystery of its first cultivation back of all written history.

A botanist of great merit, Count Solms Laubach, weary of this discussion, finally advocated the idea that the wheat of the present day, with its numerous varieties, might be the descendant of plants which have to-day disappeared, either because their home was submerged by the sea or because they were the result of a convergence of several species deviating in the same direction or mixed in cultivation, which would make the determination of their origin almost impossible.

In the universities the view has generally been held that the home

of the wheat would always remain unknown and that our cultivated species had been so greatly modified by cultivation that they scarcely resembled the wild species which served our prehistoric parents in their conscious or unconscious attempts at artificial selection. This transformation, it was said, had required ages of time, and it was not overlooked that it had also required extraordinary perspicacity on the part of these half savages who succeeded in producing from an insignificant grass the vigorous and precious cereal of to-day. It was admitted, thus, that prehistoric man was endowed with a divining sense more remarkable than that of the scientists of the present time, who, in the domain of agriculture, have never achieved results equal to this. To support this idea it might be maintained that the more primitive the people the more acute is its sense of observation. Book science very often sterilizes the excellent mentality natural to youth and also limits the imagination.

However, I remember that when for the first time I found wild cabbage growing on rocks at the seashore remote from all cultivated fields, I was struck by the fact that even with my limitations of an educated man and with all the mental deformation attendant on scientific specialization which leads one away, they say, from common sense, I should nevertheless, it seemed to me, not have hesitated, in case of need, to try this plant as food, so inviting was its appearance. Last year, in my botanical trip along the coast of Portugal, I was able to see that the Portuguese peasant, who has kept so many vestiges of the past in his dress, his domestic animals (long-horned cattle), his cart and his customs, still uses the cabbage (Covo-gallego) as primitive peoples would; the flower tops are simply boiled. There is a far cry from this cabbage still so near its primitive state to the numerous varieties which the agriculturists have introduced into our European cultivation.

There is, then, reason to believe that primitive man found the plants suitable for cultivation already showing the principal attributes which make them useful; he found the cereals, he did not create them. In other words, cereals are the cause of civilization, not civilization the cause of cereals.

Alphonse de Candolle, the illustrious father of the president of the Société des Arts, in his classic work on the origin of cultivated plants, in 1883, says:

> The Euphrates region, lying about in the middle of the zone of cultivation [of wheat] which formerly extended from China to the Canary Islands, was very probably the principal habitat of the species in very early prehistoric times. Perhaps it extended towards Syria, as the climate is very similar, but to the east and to the west of western Asia wheat has never existed except in a cultivated state, antedating, it is true, any known civilization.

This brings us to the main issue of the question which I wish to study with you.

About 1902 two German botanists, well known in Geneva, Ascherson and Schweinfurth, called the attention of a young agronomist, Mr. Aaron Aaronsohn, who was destined in later years to become director of the Haifa Agricultural Station in Palestine, to the scientific and historic interest of determining the truth of a suggestion made by Kotschy. This collector brought back from Syria a fragment of a wild plant which Körnicke, an authority on cereals, recognized as a form of *Triticum dicoccum* and which he made a variety under the name of *T. dicoccum dicoccoides.*

From this mere indication Körnicke drew the same conclusions as those A. de Candolle had reached by another road, *i. e.,* that wheat must be indigenous to Syria. In the course of a geognostic expedition in Upper Galilee to the north of Lake Tiberias, Mr. Aaronsohn gave his attention to this question, although he was very dubious about being able to answer it.

As a matter of fact, modern botanists who have studied the flora of Syria, such as Dr. Post, have not confirmed Kotschy's doubtful indication. On the first expedition Mr. Aaronsohn found nothing, but urged by his friends in Berlin he went to this same region again, and this time his efforts were crowned with success. In June, 1906, being at the north of Lake Tiberias at Rosh Pinah, he found a single specimen of the wild emmer (*Triticum dicoccum dicoccoides*) growing in a rocky fissure. Complete success came, however, only on leaving Rasheya, where wild wheat abounded in uncultivated ground. Having climbed Mt. Hermon, he descended on the opposite side, and towards the village of Arny wild wheat was also very common and showed here an extraordinary variety of forms; black glumes or only partly black, black or colorless heads, smooth or hirsute glumes, glumes sometimes resembling those of *Triticum monococcum* (einkorn) or *Triticum durum* (hard wheat), heads of the type of *T. polonicum,* etc. Among these plants there was also the wild einkorn (*T. monococcum ægilipoides.* This excessive variation, the abundance of these plants, their distribution on the slopes of Mt. Hermon from an altitude of 1,500–2,000 m., all show that the plant is certainly indigenous. It is a known fact that our cereals do not spread beyond cultivation in any country and that however extended their cultivation may be they never become subspontaneous. In order to establish itself in any locality a plant must hold its own against competitors which, masters of the soil from time immemorial, have been selected to fit the soil and climate. Moreover, emmer is not cultivated anywhere in Palestine. This wild wheat is furthermore a different plant from any known in cultivation, a polymorphous race, no doubt, but a distinct

one, to which Körnicke had already given the varietal name *dicoccoides*. No intermediate form between this wild plant and those cultivated in Palestine has been found. Thus everything tends to show that wheat is indigenous to Mt. Hermon. Somewhat later, Mr. Aaronsohn discovered *Secale montanum*, the wild rye, in Antiliban. For philological reasons it had formerly been thought that this was indigenous to Europe. From now on we must bear in mind that this cereal also has its center of distribution somewhere in Asia Minor.

That wheat was indigenous to Palestine was to be confirmed somewhat later by the same explorer. In 1908, while on a mission for the Turkish government, Mr. Aaronsohn discovered wild barley, already known at other stations, in the Moab country on the left bank of the Dead Sea, above El Mazra-a; towards Wady Wahleh monoliths occur in large numbers and round about are many chipped flint implements. The Jewish savant could not keep his fancy from roaming. He went back in spirit to that far-away epoch, more ancient than all written history, when urged by hunger while crossing these steppes, primitive man first tried these savory grains and discovered cereals.

A little later in this same region of the Dead Sea, while on a second expedition, Mr. Aaronsohn found emmer in great abundance, towards Tel Nimrim, in the valley of the Jordan, at Ain-Hummar, on the plateau of Es-Salt.

When one considers the fact that the grains of wild wheat are not inferior either in weight or size to those of the best cultivated species it would be impossible not to arrive at the conclusion that primitive man did not create cereals, he found them.

One can imagine the nomads of the hills and mountains of Palestine, giving these precious seeds to the inhabitants of Mesopotamia, who were better situated than themselves for the testing of crops and who succeeded with them in their rich alluvial plains. Glancing at the Assyrian bas-relief, we are struck by the great importance given by this people in their ceremonies to the mystery of the seed which contains within itself the essence of life and, in consequence, the intense interest which they manifested in all agriculture.

One of the most striking things in economic history is the rapidity with which a new food or useful plant spreads even to little-civilized countries. Schweinfurth, in his famous voyages to the heart of Africa, found tobacco grown by the most primitive peoples. Hooker, exploring the high valleys of the Himalayas, found the potato cultivated by the Lepchas and the people of Nepaul, scarcely half a century after its introduction into Europe as an important cultivated plant.

I have told in detail of the important discovery of Aaronsohn. Let us see now what practical and scientific results can come from it.

In order to do so it is necessary to explain to you as briefly as possible the present state of biological science and the modern way of considering the problems relating to species.

Modern botany, abandoning the ancient methods which depend more on metaphysics and speculation than on experiments, has given up the idea of discovering the origin of species by the prevalent method of comparison and reasoning. The separation of forms, of varieties and of species, as it is made by systematists, the herbarium specialists, is based on judgment; it depends essentially on the degree of intuition of the botanist who compares and draws conclusions. I do not mean to say here that the methods of this science are conjectural, but I may be permitted to say that it is only an outline of a science, that it is provisional knowledge, a first attempt at classification. More precise methods are necessary in order to resolve serious biological questions. The best representatives of contemporary biological science are much less hurried than their predecessors; they have acquired the conviction that there is no short cut to truth. The scientific highway is paved with difficulties. In this explanation, then, I shall not touch upon the evolutionary speculations of Darwin or others, but shall give my time exclusively to exact data.

Contemporary biology accepts the constancy of types as a well-established fact. It has discovered that this constancy is experimentally demonstrable if the following facts, not known to Darwin and his followers, be taken into account.

Every species in its natural state, and often even in cultivation, includes a large number of forms which were formerly considered variations, but which, analyzed by modern methods, appear to be constant types, all of which taken together form the Linnean species. In order to discover these small constant species which ordinarily live mixed together, it is necessary to segregate them. Vilmorin had already recognized that unequivocal results could not be obtained in the study of variation if one starts with an isolated plant or even with a single seed. A single grain of wheat may be the ancestor of innumerable generations. If these isolated grains, carefully catalogued, be sown separately, it is seen that they give birth to constant races or lines which are called pure, because they are without mixture. To evaluate these lines and differentiate them from other lines, we must not consider the isolated individual, but rather note the character of the descendants as a whole by means of experimental pure cultures. The individuals of the same race, of the same line, may differ very much according to their age, nutrition, position during the embryonic or ontogenic development, but their descendants taken as a whole are identical. In a pure race, the dwarfs as well as the giants give birth

to a mediocre line having the same average size (and other values which I can not cite here). In other words, the sum of the descendants is identical with the sum of the ascendants.

Each race differs from the others in form, stature, hardiness and chemical composition. The name population has been given to the mixtures of races, such as nature gives us in a meadow or such as we have in cultivation when segregation has not been carried far enough, that is to say, when pure lines which can be distinguished have not been separated grain by grain. This practise of selection, according to Vilmorin, has already been tested not only in the vast field of theoretical botany, but also in that of applied botany. At Svalöf, Sweden, cereals are selected according to this principle by evaluating the differences by numerical methods. All agricultural Europe follows with special attention the classic experiments of Nilson and his collaborators.

Except for the very rare phenomenon of spontaneous variation (mutation) we can by beginning with these pure lines operate in a practical way, with almost mathematical certainty, the probable error being minimal. In cereals, and especially in wheat, the characters to be studied which will be constant for a given race are: stooling, regularity of growth (that is, greater or less individual variation), average weight of the grains, resistance of the straw to lodging, length of the straw, form and length of the heads, composition of the grain (starch, sugar, nitrogen, fat, etc.), disease-resistance. In the short time at my disposal I can not explain to you the ingenious methods used to determine with precision these different characters. I wish to add only one thing. Each of these characters or their combination in pairs or groups determines the probability of success and good harvest in a given locality, and, in consequence, the more constant forms, the more pure lines there are, the more prepared will scientific agriculture be to furnish to cultivators races which will suit their soils. Now if you consider that these problems are among those that chiefly interest mankind, which demands each day its daily bread, you will understand that the slightest discovery which makes for the betterment of cereals means a noticeable increase in the wealth of a nation. If France is one of the richest countries of the world it is because her wheat production is superior, in respect to her territory, to that of all her competitors.

Now, modern agriculture, given new life by botany, has obtained in France, Germany and other civilized countries, a considerable number of these varieties, starting from cereals introduced into our country in the course of the long history of civilization; that is, from times more ancient than any documents written on parchment or carved in stone.

But let us remember the important results of Aaronsohn's discoveries: Primitive man, even he who chipped the flints abounding about the menhirs of the Moab country, as he sought his food in the steppes, found fields of cereals waving in the breeze just as the graceful heads of *Stipa* sway in the breeze of our fields of our canton of Valais. The wild wheat, *Triticum dicoccoides,* with its large grains, must have immediately caught the attention of a primitive people, interested in nature as are all peoples whose eyes have not been closed and whose sense of observation has not been dulled by too much book learning.

Is it not a singular coincidence that this young Jew, Mr. Aaronsohn, should rediscover in Judea the origin of our cereals, of our civilization? There is material in that for a philosopher or a historian to write a moving page. I have the pleasure of counting Mr. Aaronsohn among my botanical friends, and I may say to you that rarely has an important discovery been made by a more genial and charming man. Those who say that man is master of his fate may well cite him as an example. But let us rather listen to him:

JEWISH AGRICULTURAL EXPERIMENT STATION
HAIFA, PALESTINE

26 Jan., 1911

MONSIEUR CHODAT,

Professeur à la Faculté des Sciences, Genève.

Dear Sir: I have just received your kind letter of the 3d inst., which recalled to me our agreeable and interesting conversations during the Congress at Brussels. I am very much flattered to learn of the subject that you have chosen for the annual meeting of the Société des Arts.

I shall be glad to send you the "corps du délit" which you wish; I shall also take the liberty of sending some photographs taken last June which will give you an idea of the appearance of the fields where my *Triticum* flourishes. You will doubtless be glad to learn that we have this year sown more than an acre of *Triticum dicoccoides.* We intend to study the value of this plant for forage, etc. I had the good fortune to discover in Upper Galilee this year a spontaneous hybrid of *Triticum* and *Ægilops,* and there also exists already a wheat with a non-articulate rachis, arising from a cross of my *Triticum* and a cultivated wheat. Thus you see that we are rapidly advancing towards the realization of our dream. In the different experimental fields where my *Triticum* has been grown it has resisted rust very well, and this for three or four successive years while many check varieties succumbed to this disease. In these times of "unit characters" it should not be difficult to fix this special property of disease-resistance, and you will at once realize the practical significance and the economic value of this character.

As for the problem of the origin of civilization or the origin of wheat culture, I have resolved upon a new method of attack. I had first taken up the study of adventitious plants accompanying our cereals. Thus the discovery of *Lolium temulentum,* quite spontaneous in a given region, far from all cultivation, would be a sufficient reason, in my opinion, for inaugurating a search in this neighborhood for the cradle of our cereals. Now, I am on another trail.

I wish to study the cryptogamic diseases of my wild wheat in order to try to discover if among them there are any peculiar to wheat in other regions and which here would attack other plants. We could then say this or that cryptogam was carried by cereals and would be found in the same situation in relation to wheat, as certain phanerogamic satellites such as *Lolium temulentum, Githago segetum,* etc., etc.

I am sending with this letter a small photograph showing our workmen sowing *Triticum dicoccoides* with a drill. I shall not conceal from you that I am very proud that when for the first time since prehistoric times man has again tried sowing the prototype of wheat, this work has fallen to Jews (escaped from the ignoble massacres of Russia), Jewish teams working on Jewish ground, the historic cradle of the race.

Yours sincerely,

A. Aaronsohn

You perceive the wide field which this discovery has opened up. The utilization for new needs of new races of wheat to be segregated from this wild material, that is, from the polymorphic plant populations of the hills of Judea, the extension of the cultivation of cereals to arid regions or mountainous zones, where it has hitherto not been possible.

But there is more than that. We possess now, and Mr. Aaronsohn alludes to it in his letter, a second method of improving wheat by the method of selection, growing pure races from single seeds.

We can, by crossing, create new races and in this domain modern methods have a startling precision. They say that the man who suddenly had a new world revealed to him by the microscope lost his reason. To-day, placed in the presence of the facts brought to light by modern biological analysis, we can see in our minds an infinite line of discoveries which were not even suspected by the generations preceding us.

Here, in a few words, are the results already obtained:

They lead us to suppose the existence of essential representative particles within the germ cells of plants. These particles may be compared to the atoms which chemists suppose to exist in the inanimate world. These are the biological elements, the "organic corpuscles" as Buffon would have called them. We call them "gens." The body of the plant with its diverse characters is then only the exterior manifestation of these "determinants." We suppose, then, that each character manifested is determined by a "gen," a "determinant." To constitute an organism with its characters there must be an association of gens.

For the sake of similarity in studies on heredity plants belonging to the same systematic grouping, the same genus or the same species, are usually compared. Only the characters in which these two plants differ are taken into account. For example, a race X will differ from

a race Y by three characters, *i. e.*, by the gens $A\ B\ C$ (for example, $A =$ long head; $B =$ awned glumes; $C =$ rust resistance), to which the race Y opposes $a\ b\ c$. These are antagonistic characters ($a =$ short head; $b =$ awnless glumes; $c =$ capacity for rust infection). A is the antagonist of a, B of b, etc. But A is not antagonistic to b or c, nor B to a and c.

As long as the plant is self-fertilized, the mosaic of its characters is maintained. But if it is fertilized by a distinct race several cases can arise in the course of successive generations. The product called a hybrid ($F_1 =$ filius 1) is evidently the sum of the two parents ($X + Y$); if forms not closely related to each other are crossed, the hybrid generally takes a form intermediate between the two parents. We shall not speak of these hybrids here, for they are generally sterile and practically useless for cereal culture. If, on the other hand, closely related forms are fused in the hybrid (F_1) the characters of the father or the mother exclude those of the other parent; one of the parents seems to have been absorbed by the other. Then we say that the character of the father or of the mother dominates or *vice versa*. Let us take two parents X and Y, differing in the antagonistic characters $A\ B\ C$ for X and $a\ b\ c$ for Y. The hybrid ($F_1 = X + Y$) will have the appearance A, B, C, if the total gens of X dominate those of Y, or the appearance a, b, c in the contrary case. In other words, one of the parents may seem to be absorbed by the other. But it often happens that if A dominates a, b dominates B, c dominates C.

But if this hybrid (F_1) is allowed to fertilize itself, its direct descendants, *i. e.*, the second generation (F_2), show that the character or characters which had disappeared reappear in a proportion which can be predicted with almost mathematical certainty. I can not take the time to explain to you the details of this phenomenon. But the most astonishing thing is that among the descendants of the second generation (F_2) (that is, the descendants of the hybrid by self-fertilization) there are (1) those resembling the father exclusively (X), or the mother (Y); (2) new forms, *i. e.*, those in which a part of the paternal and maternal characters are combined in a new mosaic.

To choose a very simple example, if the two parents differed by their two pairs of characters $A\ B$ and $a\ b$, the hybrid of the first generation (F_1) would bear the apparent characters $A\ B$ or $a\ b$, that is, it would resemble the father or the mother exclusively, according to the predominance; that of the generation (F_2) would comprise individuals of different sorts: AB, Ab, Ba, ab. The two combinations Ab and Ba are new.

If, in a second case, the antagonistic gens are ABC for (X) and $a\ b\ c$ for (Y), the first generation might be $A\ B\ C$, but in the second

we should have a larger number of categories of types; now, of these types there would be eight categories which would be constant. These would be *A B C, A B c, A b C, a B C, A b c, a B c, a b C, abc;* two of these types repeat the primitive parents, the others are new. If these latter are not allowed to fertilize each other or to be ferilized by other forms, but are self-fertilized, they will be constant in their descendance, which will behave like a new stable species.

From this we see that the mosaics of gens, which constitute the hereditary capital of species and varieties, are dissociable and that the gens, in the phenomena preceding or accompanying fecundation, execute a sort of chassé-croisé, the final result of which is determined by the laws of probability.

The number of types and new forms increases rapidly with the number of antagonistic characters. For 2 antagonistic gens there will be 4 types; for 3 gens, 8 types; for 4 gens, 16 types; for 5 gens, 32 types; for 6 gens, 64 types; for 7 gens, 128 types—and these types are constant from the second generation (in which they appeared) on.

Here we have infinite perspectives which appear on our new scientific horizon.

But to obtain these remarkable results with the desired mathematical certainty we must start with biological unity, with a pure line, with a single grain of wheat, the parent of a whole line similar to it.

From this we see the importance of Aaronsohn's discovery; it will allow us to do methodically in a few years all that 6,000 years of cultivation and unconscious selection have gained for us and perhaps also to combine and associate characters which escaped the intuitive observations of primitive peoples.

For example, we can associate the hardiness of the wild wheat with the vigor of growth of a cultivated wheat, the rust resistance of a wild variety with the seed quality of a cultivated variety, etc.[3]

But wheat is not for agriculture, wheat is to make bread. This making of bread is almost as old as the cultivation of wheat, and yet the conditions of fermentation necessary to raise the dough under the influence of leaven are still insufficiently known. We know that in this sour dough, the natural leaven, there are lactic bacteria which secrete an acid and give off a gas as well as alcohol. By means of this fermentation the dough, permeated by the gas which raises it, gives a lighter, more digestible bread. We are far from knowing all of the details of the process of bread fermentation. However that may be, for ages beer yeast has been introduced into the leaven, or, as in the time of the Romans, the "must of fermenting wine." These yeasts

[3] Bateson, ''Mendelism,'' Cambridge, 1909. See ''Mendelism,'' Punnet, R. C., ed. 7, Cambridge, 1909, p. 58.

are minute fungi invisible to the naked eye which attack the sugar of the bread and transform it into carbonic-acid gas and alcohol. The course of this fermentation is controlled by the presence of lactic bacteria which prevent the growth of putrefactive organisms. But here again there are lactic bacteria and lactic bacteria, yeasts and yeasts. These yeasts are again populations, mixtures of different races from which the microbiologist can select pure lines. Here Vilmorin's method must be used, *i. e.,* filiation from a single isolated germ. Thanks to this process, Hansen and others have selected a large number of strains of yeasts, each with its particular character. For science of to-day beer yeast no longer exists, but in its place there are many distinct and constant species just as there are many distinct and constant species of lactic bacteria. The problem of the future will be, then, to regulate bread fermentation by means of these selected microorganisms.

But certain flours do not rise well. Suitable ferments must be found for them. Others, like maize flour, do not rise at all. It is therefore impossible to make bread from maize alone. In 1900, at the time of the World's Exposition at Paris, I was asked this question: "How can we find a ferment to raise dough made from maize?" No yeast tried up to that time had been able to accomplish this. I then thought of using ferment from India which I had procured through Colonel Prain, director of the Kew Botanic Garden. In applying these selection methods the late Mr. A. Netchich and I obtained from these ferments, which are employed in Sikkim and the Khasia Mountains for the alcoholic fermentation of rice and Eleusine, a leaven, which alone or associated with other yeast causes maize dough to rise and thus allows bread to be made from it. We dedicated this species to Dr. Prain (*Amylomyces Prainii* = *Mucor Prainii*). I take this opportunity of announcing this discovery and putting it in reach of all those who wish to profit by it.

THE INHERITANCE OF ACQUIRED CHARACTERS

By LELAND GRIGGS, Ph.D.
DARTMOUTH COLLEGE

THE variability of animal bodies is a very evident fact. The individuals of every species show variety in color, form and size. Three types of variability have been discovered; fluctuating variation obeying the laws of chance, mutation appearing as sudden loss or gain of a color or other feature, and acquired characters gained by an individual in relation to its surroundings. Among these three types are sought the great factors of evolution. It is a singular fact that no great biologist has attempted to use all three of these factors as the basis of his system, but each author has sought to build his hypothesis upon some one all-important factor.

Fluctuating variation is undoubtedly the greatest of these factors in the part it has played in the history of evolution. It was made by Darwin the corner-stone of his theory when he claimed that natural and artificial selection could produce almost unlimited effects by the elimination of all but the most favorable among thousands of variants in a species. In the debates over the general theory of evolution there has been no argument more often used than the plausibility of Darwin's theory of the survival of the fittest. The public, in accepting the truth of the theory of descent, has come to look upon this factor of fluctuating variation as a necessary part of evolution. In fact, to many professional biologists Darwinism has become synonymous with the survival of the fittest variations.

The theory of mutation is the most serious opponent of the Darwinian theory of selection of variations. Based at first on the evidence gathered by De Vries, it has grown in popularity with the growth of the knowledge of the inheritance of unit characters, and with the discovery of pure line inheritance. In the minds of many biologists it has the advantage of showing a method of rapid evolution more or less independent of the guidance of natural selection. The more ardent supporters of the theory have claimed for it the position formerly held by the theory of fluctuating variations, trying to show that all evolution must be in the nature of loss or gain of unit characters.

That the familiar acquired characters of animals should be inherited was once taken for granted, and, in fact, is still a general belief in the world at large. This theory was held by Lamarck to be a great law of evolution. It was defended by Spencer, and assumed occasionally even

by Darwin. In the light of careful experiment, however, it has been largely discredited. The verdict of "not proven" has been pronounced against it, and many biologists would go even further and claim with T. H. Morgan that the theory was "unnecessary." Yet, not content with such a verdict, a small number of workers have persisted in their attempts to establish the theory of acquired characters as one of the essential factors of evolution.

Recently the discussions of evolution have begun to take a new turn. The old attempt to find one single all-important factor is being abandoned for a broader point of view that allows the possibility of many factors, some of them perhaps still unknown. V. L. Kellogg has pointed out the smallness of the number of observed mutations on which to base a comprehensive theory. Castle, a strong believer in mutation and unit characters, has affirmed his belief in the efficacy of selection in the production of new forms. Nowhere in the literature of the last year or two can be found any very dogmatic claim for a single all-important factor which will serve as the basis for all kinds of evolution.

In this new atmosphere Lamarck's theory again receives serious attention, but not in its old form. To-day no one ventures to cite such examples as Spencer's famous illustration of the puppy that inherited from its mother the trick of begging for food. Such experiments as breeding away the wings of flies in small tubes, or breeding away the eyes of flies in dark chambers, attract but little attention. No great biologist is giving much time to experiments testing the inheritance of mutilations. On the other hand, there are many experiments to test the inherited effect of starvation, to test the effect of the application of chemicals directly to the germ plasm, and to test the effect of the application of extremes of temperature to animals with ripe germ cells. Several investigators have shrewdly seen the value of working with plastic types of animals like the amphibians, which present striking examples of dimorphism such as are found in axolotyl, *Diemyctylus* and various frog tadpoles. In this field a prominent worker is Kammerer, a representative of a school of experimental evolution in Vienna.

A short summary will be given of his researches on toads, tree frogs and salamanders. A few selected experiments will show very well the nature of the most recent work on the inheritance of acquired characters.

Kammerer in his work on the toad, *Alytes,* tried to prolong the tadpole stage until sexual maturity. He exposed the young tadpoles to a number of conditions such as darkness, cold, perfectly still water, each of which acting by itself tended to prolong the larval period. By exposing tadpoles to all of these conditions acting at the same time, he succeeded in producing one sexually mature female with the usual form of a tadpole but with mouth, legs and sexual organs of an adult toad. This one example was mated to a normal male. The progeny

at the time the report was made, while not yet sexually mature, had been living in normal surroundings for six months longer than the usual larval period. Evidently the prolongation of the larval period had an inherited effect, and the new character was apparently a dominant factor. Strangely enough no inherited effect was seen in the offspring of those tadpoles which left the water before sexual maturity. Evidently the stimulus, whatever it may be, must act on the mature germ cells to produce an effect.

Other experiments were tried on this same toad with the object of changing its peculiar instinct of caring for its young. The male, under normal conditions, plants the fertilized eggs on his back and carries them there until the embryos have reached a stage just prior to the appearance of the fore-limb buds. The tadpoles are then liberated in the water. This peculiar instinct was found to be easily modified by change of surroundings.

The combined action of heat, dryness and darkness produced an egg called by Kammerer "a giant egg." The embryo from such an egg at the time of liberation was much larger than the normal type, fully twice as large, with well-developed hind limbs. Upon leaving the water the larva produced a small adult, a change in size due apparently to lack of water in the tissues. The new form of adult laid fewer eggs, which were larger and richer in yolk. Such eggs under normal conditions produced tadpoles which, in size and form at the time of hatching, were about half way between the old type and the derived type. The new character, then, was partly inherited. The stimulus in this case clearly did not act directly on the mature germ cells, but, if the dwarf form of the adult was due to lack of water in the tissues, there may have been an indirect action on the germ cells. The effect of keeping the eggs enclosed in their envelopes on moist earth for a considerable period of time produced a type of larva called by Kammerer "a land larva." This new type when placed in the water in its usual environment appeared superficially like a water larva of the same age, but a closer examination showed that the new conditions of development on land had accelerated the growth of the lungs. The land larva had lungs with well-developed air cells, while the water larva had simple sac-like lungs. The inheritance of the newly acquired character was evident, in that the embryos of the second generation could be kept on land for a much longer period before they began to show any ill effects from their unusual environment. Thus there was, according to the author, a progressive adaptation to land life through the inherited effects of environment.

In the presence of a relatively high temperature, the mature toads were constantly in and about the water, and in the breeding season mated in the water. The egg envelopes at once swelled up, and it was

impossible for the male to plant these "water eggs," as the author calls them, on its back. Therefore the early stages developed in the water as is the case with other amphibians. The habit of mating in the water became fixed, and persisted after the removal of the artificial conditions of temperature. The eggs, meantime, at each successive laying became smaller and smaller through the loss of yolk. The larvæ hatched at a much younger stage than the larvæ from normal eggs. The adults reared from the water eggs mated in the water at the first breeding season, even under normal conditions of temperature. Succeeding generations showed intensification of the new characters in the decrease of yolk, and also in the development of more gills, which changed in number from one pair to three pairs. There was, therefore, as in the preceding case, an apparently progressive adaptation to environment through the inheritance of acquired characters.

The effect of this change on the germ plasm was tested by a cross between the old type and the derived type. The new character, as judged by the instinct for mating in the water, behaved like a dominant Mendelian factor. Dominance, however, was of an unusual kind. The male, whether of the old or the new form, impressed its character on all the offspring of the first generation, but the second filial generation showed the usual kind of segregation of characters in the ratio of three individuals of the dominant form to one of the recessive. Clearly the unexpected feature in the behavior of the factors in this crossing lies in the peculiarity of the sex-limited potency, not in the segregation of factors. The most interesting fact in the experiment is the attempt to prove a change in the germ plasm by the modern method of applying the test of cross breeding.

Another series of experiments was tried on the tree frog, *Hyla*. This frog lays its eggs in the water in bunches of 800–1,000, enveloped by the usual coats of gelatine. A number of frogs were kept away from the water, but were allowed to crawl about on a water plant which held small amounts of moisture in the bases of its leaves. During the mating season the frogs deposited their eggs in the moisture on the leaves, according to a habit which is common among some of the tropical representatives of the genus. The young remained in their envelopes until the gills had become enclosed, whereas the young under normal conditions begin a free swimming life before the gills appear. A new type of adult was produced marked by its small size. These dwarfs when reaching maturity laid their eggs in water after the usual manner. The new habit was not inherited. The offspring of the dwarf frogs, however, had external gills at the time of hatching, a stage half way between the old and the derived type, and, moreover, they grew into adults of a size half way between the two types. This experiment, therefore, showed results very similar to those shown by the experiment on *Alytes*.

A third series of experiments was tried on two European salamanders, *Salamandra ater* and *Salamandra maculosa.* The former is a black mountain salamander which has the peculiar habit of bringing forth its young alive, always a brood of two with lungs already functional. The embryos pass through their early development in the body of the mother, nourished by the yolk of eggs that fail to develop. *Salamandra maculosa* is a yellow-spotted salamander of the lowlands which lays its eggs in running brooks. When kept away from the water the female of the spotted salamander at first dropped her eggs on the ground directly after fertilization. Such eggs failed to develop. In the course of two years, however, this salamander gradually acquired the habit of holding the eggs in the body for several weeks. The eggs became fewer in number and larger in size until the young were brought forth alive in a condition like that of the black salamander. Females of the latter were treated in an exactly opposite way. They were kept in or near the water until they acquired the habits of the spotted salamander. Inheritance was imperfect in each case. The new type of spotted salamander, under the usual normal conditions, deposited in the water a brood of five fairly well developed young. The new type of black salamander, under normal conditions, deposited in the water a brood of three young in a stage of development more advanced than that of the spotted salamander. When the artificial conditions of the experiments were continued through two generations the effect was greater. The author claims that his experiments show the inheritance of acquired characters influencing structure and instinct.

A second experiment was tried on *Salamandra maculosa* to test the inheritance of acquired color due to change of background. A brood of young salamanders was divided into two lots, one of which was kept for six years on a background of yellow, the other on a background of black. The former showed a decided increase in yellow markings, the latter an increase in black markings. The young of the yellow type were allowed to begin their development on a background of neutral tint, but before reaching maturity the brood was divided as before into two parts and placed, one part on a yellow background, the other on a black background. The set on yellow, after two years, showed a great increase of the yellow markings as compared with their parents, in fact the yellow pigment nearly covered the body. The set on the black background showed more black than their parents, but less black than the previous set similarly treated but of normal parents. These experiments, according to the author, show the progressive effect of environment in the inheritance of acquired colors.

The evidence presented by these experiments, which have been briefly described in the preceding paragraphs, should be considered in

the light of the most recently discovered principles of heredity. A very important conception in this connection is the continuity of the germ plasm, another is the variability of the potency of unit characters.

Admitting, then, that certain acquired characters have actually appeared in later generations, we should consider, first, whether or not the germ plasm has been changed by the stimulus which has produced the changes in the body. It has been shown that starvation in the larval stages of insects will produce dwarfs in later generations, but here it is assumed that the unfavorable conditions surrounding the germ plasm persist and that there is no real change in the composition of the germ plasm. Can Kammerer's results be explained in the same way? Of course a Lamarckian can not be asked to produce a form which will not revert. The only test that can be readily applied is that of Mendelian inheritance. It has been shown by the author that in one case at least the new factor behaved like a Mendelian factor. Tower also found this true in crossing a pale potato beetle, which he derived experimentally, with a beetle of the normal color. Such a test to discover a change in the composition of the germ plasm is certainly very significant.

Granted, then, that the germ plasm has been changed, we should next consider whether it has been changed directly or indirectly. The experiment of keeping tadpoles in water for an abnormally long time showed that in order to affect the next generation the stimulus must continue to act until the sex cells are mature. Tower also came to the same conclusion in his experiments on the potato beetle where heat was the stimulus. The changes, then, are probably due to the direct action of chemical and physical stimuli on the germ plasm contained in the ripe germ cells, exactly as MacDougal produces mutations, as he claims, by injecting chemicals into the ovary of a plant. But why should the stimuli not effect the germ plasm of the embryo as well, since, according to the theory of continuity, the same plasm is always present even in the youngest stages? It may possibly be claimed that, if any such effect is produced in the embryo, the change is repaired before reproduction takes place.

Granted, then, that the germ plasm in these cases is more or less directly affected by the environment, we should consider whether the change is more than a change of potency of a factor already present. According to Castle such potency may be increased by selection. Perhaps the new environment may increase in some way the potency of a factor which is present in a weak condition. For example, in the case of the spotted salamander, the potency of the factor represented by the yellow pigment may possibly be changed by the action of the yellow light, which actually increases the amount of the pigment in the body of the adult until perhaps the nature of the fluids of the body cavity

are affected and hence the germ cells themselves. Certainly such interpretations, while the merest speculations, are hard to deny from the known facts.

In such theoretical discussions of the nature of germ plasm and the potency of factors biologists are very apt to lose sight of the true historical purpose of the hypothesis of the inheritance of acquired characters. The real question to be answered first is whether or not acquired characters actually appear in following generations to such an extent as to make real contributions to the course of evolution. Even if the so-called inheritance is really a change in potency due to the direct action of stimuli on the germ plasm, nevertheless, the Lamarckian factor may be a real factor. We have not explained away any process by showing the method of its operation. The real question to be decided should be stated broadly. Do new habits and new environment produce changes in form which are of importance in organic evolution? While a final answer can not at present be given to the question, it may safely be stated that a renewal of interest in Lamarck's factor is justified by the results of recent research.

CANST THOU NOT MINISTER TO A MIND DISEASED?

By Dr. SMITH BAKER
UTICA, N. Y.

WITH respect to this most pathetic question of the sick-room, the good Doctor in "Macbeth" seems to have exhausted the medical possibilities of his time, in his answer, "Therein the patient must minister to himself." Moreover, had he tried, though never so devotedly, to remove from Lady Macbeth's mind the "thick-coming fancies that kept her from her rest," he would have almost ignominiously failed, not only to "cure her of that," but equally to

> Pluck from memory a rooted sorrow,
> Raze out the written troubles of the brain,
> And with some sweet oblivious antidote
> Cleanse the stuff'd bosom of that perilous stuff
> Which weighs upon the heart;

and all this, in spite of the dangerous gravity of the case, and his royal employer's urgent need.

Indeed, not only then but always, even until now, has the skill requisite "to purge to sound and pristine health" the mind thus seriously troubled been so generally wanting, that it does not now seem amiss to point out once more some of the difficulties which lie in the way, and likewise to indicate wherein, to some extent at least, surer and more permanent means of success than those heretofore used may be looked for, if not just now, then in the near future.

In this worthy undertaking, even Macbeth himself, by his remarkable diagnosis, may help us to make a more promising beginning than his contemporary physician could possibly make, at that time, and without necessarily becoming involved in so many of the mistakes which otherwise might seriously obstruct vision and paralyze action as well. To the king, stunned, remorseful, apprehensive as he was, the case presented, notwithstanding, certain very definite characteristics, which, in his rather picturesque classification, may be noted as "thick-coming fancies," "rooted sorrow," "written troubles," and the "stuff'd bosom" that "weighs upon the heart." Looked at in the light of modern knowledge, this list of insistent ideation, deep grief, visual hallucinations, morbid apprehensions and fears, guilty conscience and depressed emotions, are seen to make up still a very large percentage indeed of the sufferings of those who are looked upon as having either potentially or

actually a "mind diseased," and who have imperative need to be cured, if possible.

Yet, frequent as this kind of disease is, great as is the suffering, so often prolonged indefinitely, and so often full of hindrance and atrophy and danger, it yet remains a matter of very common observation, that anything like a full understanding and appreciation of its real significance, or a desirable possession of efficient skill in its management and relief, is almost as unusual now as it was when Lady Macbeth's "amazed" physician so fumbled in his answer to Macbeth's demand, "Well, well, well. . . . This disease is beyond my practise. . . . More needs she the divine than the physician," but consoled himself so complacently by adding, with by no means unfamiliar unction, "God, God forgive us all!" and thus justified Macbeth's, "Throw physic to the dogs; I'll none of it," with an unsuspected completeness!

Nevertheless, no matter how incompetent Macbeth's physician felt himself seriously to be, one now feels, especially in the presence of actual cases, that the acknowledged darkness respecting the more common conceptions of a "mind diseased," or more definitely, "mental pain," and all its invaliding consequences should not continue indefinitely to prevail; and also, with equal warmth, that with more accurate knowledge there ought to come a better and still better practical skill in dealing with it, both by way of cure and prevention. Much promise of this there certainly now is, especially in the rapidly accumulating reports of those who have recently devoted themselves to careful investigations of the varied substrata of consciousness, through certain ingenious yet well-considered processes known as "psycho-analysis"; through careful study of the effects of fright, whether experienced during waking hours or in natural dreams, and as recited by those who remember and are competent to give them form; through studies of autohypnosis, and various induced "hypnoidal" conditions and the records of what is thus revealed; to which may be added a like study of the contents of certain waking trance-like or semi-hypnotic dreamy states; the coming and going of "tunes in the head," and all the other distressing trains of "imperative" ideas and impulses ("obsessions"); as well as, possibly, an entirely new series of results to be obtained through photographic records of changes in facial expression—*i. e.*, through accurate observation and interpretation of the "physiognomical (phiz) reflex" through all these, together with much other probable investigation along lines yet to be uncovered—all of which must before very long certainly add almost beyond calculation to our present knowledge of a "mind diseased" in itself, as well as of our means for its successful alleviation.

In connection with this, there undoubtedly appears something like an imperative duty on the part of all to help on these investigations and thus serviceably pave the way for practical application of what may thus be

gleaned as rapidly and as fully as possible; while to any one who has personally reached the point where he can carefully differentiate the essential features of the more frequent cases of a mind diseased, as these appear in different communities or families, and especially to one who has come more or less to fully appreciate some or all of its discouraging perplexities, depressions, fears and apprehensions; or its disappointments, emotional perversions and interferences; or the accompanying loss of confidence and hope, inordinate sense of dependence, seemingly irrevocable detachment from human and divine fellowship; and perhaps something of the shame and degradation, the general unfitness for planning work, and the conscious inadequacy of power to do it, incident thereto;—who has in fact rightly comprehended what goes to make up dire *mental pain,* and the inevitable "sickness of soul" that centers in and clusters about the innermost selfhood in all these distressing cases—to such an one a prompting to further study and to more skilful practise, as well as to enthusiastic hope regarding it all, becomes so irresistible that any suggestion of apology for even intrusive interest and propaganda is not to be thought of.

With respect to the manner in which this kind of suffering comes to be, it may be said that almost every unusual experience has in it one or more elements of causation of subsequent mental pain and derangement. Most certainly, even such experiences as broken bones may lead to it; likewise, post-infections as well as certain endogenous poisonings are sources not to be neglected; also, too many children, too heavy financial burdens, too prolonged hours of arduous labor, physical or mental; too overweening or unrealized ambitions; or poorly cooked food and noxious air; disappointed love or social aspiration; financial reverses and other forms of "ill-luck"; as well as unsatisfied deeply implanted longings of every sort; weak will or over-emotionalism; gluttony and laziness; early impressive childish experiences, especially terrorizing dreams, frightful shocks, prolonged perversions of development; gloomy or inadequate education; unpropitious parenthood; vicious or disturbing neighborhood—all these may contribute, in incalculable proportion, yet never except by their due share, either to the genesis of a mind painfully diseased, or to its prolongation and deepening, or worse still, in many instances, to most serious interference with cure.

Thus, by way of particularizing in respect to our present purpose, let us consider an instance where the mental pain has developed in the course of recovery from some kind of not unusual physical injury, or of ordinary infection from without.

In a certain proportion of such cases, it is to be noted, especially in the more impressionable constitutions, that long before the physical trouble or infection can be recovered from, even though most prompt and efficient measures have been resorted to, the tendency to the de-

velopment of mental pain has become so marked and the results so deeply registered, that it is with great difficulty and only after much time that it can in turn be recovered from, if ever at all. Could we ever have accurate data or skilled experience enough to enable us truly and properly to differentiate the readily impressionable and weakly resisting, from the less impressionable and fully resisting, constitution, the problem of what to expect and consequently what to do by way of prevention in these cases would be much simplified. But here as elsewhere our knowledge respecting inherited traits and tendencies is so vague that practically it is not to be relied upon, at any rate very absolutely or very generally. Hence, it follows, beyond question, that the universally better way is to secure complete recovery from every sort of physical trouble, no matter of what nature or how severe or otherwise, as quickly as possible, and likewise during all the time required for this to sedulously guard against the invasion of mental invalidism with as much determination and skill as against renewal of the injury, or against contagious diseases or other purely physical complication; and if, perchance, mental pain does appear, then promptly to apply such corrective measures as will prevent, so far as possible, its further development into a permanent after condition. Nipped thus at its inception mental disease as a concomitant and resultant of physical trauma or infection can often most surely be; and the outcome to the sufferer is of the nature of a benefit that is simply incalculable.

Important, however, as this theoretically must appear to every one, how frequently, notwithstanding, is exactly the opposite seen. During the process of recovery from physical injury, not only is there incredibly often little or no thought given to the possibility of an original simultaneous psychical "insult," or to subsequent consequences which may be owing to necessarily prolonged distress and confinement and weakening; on the contrary, how often likewise does it seem as if everything untoward was most unwittingly allowed, or made, day by day, to conspire to deepen the impressions of the original experience and whatever immediately follows, as well as to make doubly sure that what was at first but truly accidental and comparatively harmless, shall almost designedly be made to develop into something which in the end must prove to be as permanent and blasting as it was unexpected. Into this conspiracy, not only do the immediate friends and acquaintances of the sufferer often most thoughtlessly enter, but, and it is strange so frequently to note, do those higher in authority and responsibility likewise as unwittingly enter and remain, with a resulting summation of consequences to the sufferer, which in the given case simply defies anticipation or even estimation. Nor in this connection should the rather too frequent untoward outcome of ordinary operative procedures and post-operative care be thoughtlessly passed by. Sometimes, even on the

operating table, or more frequently during the period of recovery from anesthesia, or, in fact, at any time later, the sensitive mind may thus receive impressions which may persist permanently and prove to be sources of painful invaliding beyond all expectation. In fact, it is beyond question true that the real importance of psychical insult as a close fellow of physical injury, or the danger from the stresses and other conditions following, should in every case receive a much more thoughtful consideration from all those who have to do with it, than ever has been or is now the rule. We blame and punish those who do not provide against the consequences of the physical injury itself, or against the invasion and development of endangering infectious diseases. But often these, bad as they are, are of little consequence, compared with the results of inadequate or bungling care of the psychical insults, and subsequent untoward impressions and tensions, which so often accompany or follow physical conditions, whether accidental or designed. Certainly, it were better to have a pitted face or a crooked leg than to go through the remainder of life with irrecoverable mental imperfections and distresses. Better a weak back than a weak will; the loss of a member than the loss of normal ambition and hope; better physical pain with the mind free than mental pain with the body useless because of it!

Everything that may be said about prevening the anticipation and prevention of mental invalidism in conditions that are naturally but incidental to physical trauma, may be said, also, and with even greater emphasis, with respect to its connection with the beginning or course of a large number of cases of ordinary illness, including, as these usually do, noticeable weakness, certain depressing autointoxications, incidental effects of use or abuse of various drugs, and more or less prolonged and nearly absolute isolation—favoring conditions that are almost always more or less necessarily experienced. Here the laity, especially if not checked, are liable as a rule to as unhesitatingly as unwittingly convert any sick-room into a fateful "gossip-room" of such a horrifying and dangerous character, that even a well person may wisely shun it for safety if not from choice; while those in authoritative command likewise seem somewhat too frequently not to realize with anything like becoming fullness the deep and abiding injury which inexcusable thoughtlessness, as well as all manner of unwholesome speech and conduct, may so frequently lead to. More than once has life-long soul-sickness been traced to this kind of impression received during an illness, wherein the hapless victim was made to receive impressions of such a deeply searching and staying character, that forever after dire consequences have remained, to either primarily or secondarily afflict with untold and irrecoverable mental pain. Undoubtedly, it not infrequently happens, also, that certain chance speculative

remarks of physicians and nurses have altogether more to do in initiating certain painful mental and emotional currents, which afterwards develop untowardly out of all proportion to their importance, than is commonly recognized. The chance remark of a doctor once caused a really well man to go about with his hand over his supposedly diseased heart in such constant painful fear and apprehension, that he almost "went insane," and this for fourteen years, until, in fact, he was relieved by practical demonstrations that he had no such heart-crippling whatever.

Into no sick-room whatever, therefore, should any sort of lugubrious tale-bearer, conceited self-exhibitor, maudlin selfish sympathizer, or self-sufficient or careless professional *poseur* ever be admitted or allowed to remain, even when the sickness itself is of minor importance, and of inconsiderable duration, and the sufferer as yet appears to be normally minded. When ill, suggestibility is often much heightened or warped; and it frequently does not take long for the sanest invalid to become so profoundly impressed—so stung, or probed, or strained, or painfully awakened—that this may prove, because of the lessened resistance at the time, to be the source of troubles which may develop literally and last forever. Of course the danger varies greatly with different people, as well as with the kind and duration of the shock and stress suffered. Some people are naturally too "thick-skinned" to be easily or much affected by any such thing; but much more frequently than is suspected is it otherwise; so frequently, in fact, that it is by far safer always to keep the atmosphere of every sick-room, from beginning to end, so pure and bracing that the sufferer's mind, as never elsewhere, shall be quite exclusively impressed by what alone is of good report, and consequently uplifting and fortifying. As to the common practise, especially during the most susceptible period of all, that of convalescence, with a view chiefly to mental diversion, of reading or hearing read the common newspapers with all their tales of undermining horrors and wrong, or the "latest" novels which are so aften but mere travesties of the higher human longings and thoughts and modes of living, scarcely too severe condemnation can be urged. One can never anticipate what untoward atavistic reminiscence may thus be called up, even in the strongest minded, or what former harmful personal experience may thus be made once again distinctively to renew its life; nor can one in either case very probably estimate the permanent vitiation of mental strength and ease which may follow. Better by far most certainly to encourage, instead, the perusal of that literature only which is at once clean, strong, inspiring and rightly awakening, and thus to get the untold benefit of such a veritable "soul-bath" as can certainly be relied upon in so doing. Indeed, there is no question that, when such simple, strong, wholesome sentiments only are thus allowed regularly each day or hour to influence

the susceptible mind, it may eventually prove to be more useful in obviating and relieving the "mind diseased," than almost any other simple measure that can be thought of.

Third, let us now consider another different yet quite as prolific source of mental pain and its resulting invalidism, namely, that which is to be found in the ever-insistent consciousness of *misfit* into the ever-growing complexity and demands of the life of to-day, the necessarily consequent failure to realize what has been legitimately expected and striven for, and all the mental wear and tear which so necessarily follows or accrues.

For instance, when a sensitive man actually finds himself buffeted about in this world, with little or no ability to get anything like a sure foothold, and can think of no definite prospect of final prosperity for his encouragement, he naturally enough wears out his will-power as well as his sense of well-being long before his time, and consequently becomes the unresisting if not fully assenting prey to every depressing and perplexing influence about him. Or, when a woman finds that all her unique wealth of natural instincts and endowments promises to be of little demand in this conventional world, and so must go from day to day to tasks from which she derives little profit and no inspiration, she also rapidly develops a mental and emotional pain and weakness—a veritable soul-sickness—so deep and abiding, often, that the wonder is that either she or so many of her sisters ever have the courage requisite to go on and achieve so successfully as they do. Of course it were easy to say that the needed refitting in many of these cases is practically impossible; or that, even ideally, it is altogether too elevated, in any case, to be within ordinary application. Of course, too, every step on the way to securing the necessary changes of attitude in the individual's mind toward the real possibilities of his unusued or wrongly used powers and toward full acceptation of suggested ideals, or toward the determined devotion that sees success from the beginning, no matter how far from the purposed end—every step of this long way may only too generally prove, not only very arduous, but quite too discouraging for weak and wavering humanity to progress therein, or to succeed in the end. Yet could everybody as well as the sufferer himself once be led to see how such inappropriate fittings and placings and consequent failures necessarily contribute to the development of mental suffering and invalidism, and especially if they could once get an informed, vivid view of the interfering, destroying character of every such experience in its bearing upon ultimate success and happiness, not alone of the individual sufferer, but of the entire community, in every vital respect, there would undoubtedly result not only a prompt but effectual uprising against the common ineptitude and neglect in this respect. That such a true vision is widely needed is confirmed by the

fact that misfit, inadequacy and failure cause so many people to suffer from an inhibition of the powers of right perspective, and to such an extent that they necessarily come, in time, if slowly yet most surely, to the point where they can not see the comparative virtue of the strength they still have, and the work they still can do, even as they think upon and especially feel upon so uncomfortably, what they originally expected of themselves in the great battle of life.

From these and many another supporting observation, easily and everywhere to be had, it is perfectly legitimate to conclude, beyond reasonable doubt, that mental pain and its resulting invalidism is quite naturally the necessary outcome of a great variety of causes, which may be contributed to, usually, by almost every influence that either bad heredity, accident, disease, wrong education, personal over-stress, or failure, or future uncertainty, may happen to afford. Besides, in many instances, we may unhesitatingly believe that these causes may be almost viciously, if never so unwittingly, supplemented by parents, children, relatives far and near, neighbors and friends, clergymen and physicians, gossips, fools and scandal-mongers, and all others who may as potently as unwittingly conspire to produce and prolong it. Moreover, we may note that there often exists constitutionally, or that there has been developed through disease or accident, certain definite phases of an imperative tendency toward an abnormal sensitiveness to every painful or unusual impression, so much so that when this comes to be actually coupled with an over-developed fear of consequences, it may most unexpectedly make the sufferer all too ready to fall in with almost every possible kind of trend toward this form of invalidism, and to gradually become most thoroughly a coward, or even quite panic-stricken, from the very first suggestion of subsequent trouble. That with such a constitution and with such a "push" from untoward influences of so many kinds, every temporary attack of mental pain, from no matter how insignificant a cause, may help the sufferer eventually to slide into the chronic state of mental disease, especially when day by day serious measures for relief are unsuccessful, is plainly beyond question. Thus, a pain in the back, not overcome by sufficiently strenuous or prolonged measures, may quite as easily become evidence of "spinal disease," as pain nearer the front may become a surety of "ovarian cyst"; or higher up, of "cancer of the stomach"; or at the back of the head, of "disease of the brain." And once let such a wrong notion become fixed in the mind, especially of both patient and attendants, as it often does, and then be reinforced by reference to it, or by any set of persistent untoward circumstances, as all too often is the case, temporary or permanent disease of mind may follow, in the natural course of events, as surely as night the day, and with scarcely ever a bright morning in prospect.

Such considerations as these, consequently, make the question as to what may be done to prevent the development of such a condition, or to successfully minister to it eventually, an altogether most serious matter, especially in cases where not only the sufferer's own conditions and tendencies, but those of the entire environment, have to be considered.

In the first place, there can be no question that every case of a mind diseased should be as carefully investigated and as thoroughly understood as possible, and this from the very beginning. No sort of off-hand, "intuitive" pseudo-diagnosis should ever be relied upon as a basis either of prevention or remedy; the "case" is always really too complex to admit of any such guess-work whatever. Yet it is owing to just such a want of adequate investigation and accurate diagnosis that many a sufferer from mental pain has not only not received needed prevention or relief from his would-be ministrant, but has adversely most ignorantly or presumptuously been given abundant time to sink deeper and more permanently into his misery—so deep, in fact, so overwhelmingly, many times, that afterwards the utmost skill can be but partially successful—every really opportune moment having thus been allowed to pass forever by! Altogether and always, mental pain is too serious and dangerous a matter ever to be thus looked upon indifferently or ignorantly, or to be foolishly and fatally experimented with by not fully prepared remedialists.

In many instances, also, it seems to be altogether too readily assumed that what are called "imaginary" forms of this affection may be similarly slighted and mismanged—in fact, trifled with—without much thought as to what may be the consequence in the end. Indeed, it seems often to be considered as evidence of some kind of superior wisdom, to pronounce the sufferings of a given case as "purely imaginary," and so not to be "encouraged" by any sort of attention whatever. As a rule, however, it may be absolutely taken for granted that sick people, including the uncounted number of but-half-sick people, and those too who are said to "imagine" their illness, do not repeatedly or persistently make complaints without reasons that, when once understood, are seen to be really good and sufficient; and that every complaint of seemingly imaginary suffering has always something very real beneath it, which should at least be accurately ascertained and properly considered, before the sufferer is either condemned or ignored. Recent investigations into the true nature of the inner life, especially as this has been unsuspectedly determined by accidental shock and stress while yet in the plasticity of its very early stages, have thrown much light upon many of these perplexing types of mental invalidism in older people; and it is more than probable that further scientifically directed research will make still clearer much that is now so obscure and inexplicable. Hence, it must legitimately follow that every sort of shallow conception

of mental pain will in time give way to conceptions that will be much more nearly correct, as they will be less cruel and dangerous.

However this may be, one need not hesitate to affirm to-day that we already know enough to make it absolutely unjustifiable in any case to make a "snap" diagnosis in favor of some "imaginary" disease which may be ignored or crudely managed, as ignorance, or whim, or presumption may dictate. If it be criminal to misinterpret or neglect physical ailments, it certainly is no less so thus to seriously neglect or bungle the more delicate matters of the diseased mind.

At the outset, then, every sufferer from mental distress has one inalienable right as well as the greatest need, namely, that his trouble shall be thoroughly understood, and that this understanding shall be based upon adequate investigation of *all the facts* involved in its origin and development. This, for one very important thing, will reveal unmistakably that every one of these poor sufferers from dire inadequacy, apprehension or discouragement, and from slowing and shallowing of faculties, and glooming of every outlook, are really experiencing a kind of suffering whose original and persisting causes are not less real than are those of physical suffering, although such causes may often, if not always, lie altogether too deep in the personality to be either self-discovered, or "intuitively divined," or superficially or too promptly judged. Again it will soon appear, even not less convincingly, that if such sufferers presume to rely upon self-investigation or self-treatment alone, or upon the offers of even the shrewdest ignoramus or most devoted "curest," they will most likely find themselves from the first but painfully misled and thwarted at every step, and eventually becoming more and more deeply sickened and more thoroughly discouraged than ever. It must be remembered that this kind of pain, the pain of mental disease, is always so indissolubly a part of the innermost self and bound up with its every impulse and movement; is withal so unexpectable and incalculable, so dominant and threatening, so undermining and degrading, and positively intrusive; in fact, so devilish and selfishly excluding; so monopolizing in all its tendencies and demands, that the sufferer must necessarily find himself, no matter how skilful in even his most resolute attempts at self-relief, much more frequently in the position of one who would lift himself by tugging at his boot-straps, than otherwise, and eventually not thus to be especially helped, no matter how much he tries; while as to the outcome of the hit-or-miss remedies and practises of every sort of unqualified remedialist, whether "regular" or otherwise, to which the discouraged invalid so often goes, it must be said that ultimate failure applies equally often, and with even more force. Practically speaking, it quite regularly occurs in these cases that there develops eventually the firm, almost immovable conviction of the futility of everything which might other-

wise promise relief—a conviction that correspondingly adds to the peculiar kind of dejection and endangering, which, in turn, develops into a chronicity that may evade every attempt at remedy, later on.

From what we have discovered as to the origin and development and character of mental invalidism, then, it must again be readily recognized that it does not help this sort of individual much, if any better, simply or most elaborately to have said to him, even by the best qualified, "Oh, brace up; be a man!" or anything else of like sententious order; except, perhaps, as a "starter," when it is often undoubtedly invaluable, as is also the temporary good influence of many another similar command, or prayer, or treatment. In respect of this acknowledged initial good, however, it must always be remembered that the sufferer from a mind diseased does not, can not, thrive for very long on any sort of "starter" alone, even when it is given with best intention and high emphasis, and by those otherwise skillful; indeed, it frequently appears that the very effort to "brace up" or otherwise yield to the dominating spirit serves not to secure anything like the promised relief, but simply more firmly than ever to glue attention to the insistent distress, and to contribute immeasurably to its vividness and persistency. Nor does the heartiest promise of "better times" in the future often do much more; for in such cases the sufferer himself sees altogether too clearly how near to pretense or fabrication such a promise probably is, to be able even deceptively to draw comfort or strength or other kind of remedy from it. The fact is, this species of even most authoritative remedial platitudes do not so often touch the real "spot" as is supposed; and usually for the simple reason that the real "spot" is not even suspected by either the remedialist or the sufferer; while the reaction from ever so shrewd remedial adventuring, when it seems to promise the impossible or proves to be fallacious in the end, almost always contributes to a measurable increase of the original distress, or else to the development of some new form—"the slings and arrows of outrageous fortune" having been thus but refurbished and resharpened, rather than effectually blunted and broken, by the insufficiency of remedies and promises, which, being not properly supplemented by others appropriate to the subsequent needs, soon lose even their initial value.

Practically, it is also found in many cases, that it is just a similar kind of wrong management on the part of even those who have heretofore been the most intelligently and skillfully concerned, which has led sufferers from mental invalidism to respond so very frequently, and often so very satisfyingly to themselves, for a time, at any rate, to the offerings and importunities of "irregular" practitioners, and of irregular sects of almost every description. The "mind diseased," not getting expected, and perhaps promised, light through "instruments of pre-

cision," and not getting much-needed relief from remedies directed even legitimately to organs and functions of the body alone, often grasps naturally enough at shrewdly proffered "cures" or "healings" which promise satisfaction beyond doubt from no matter what irresponsible source, and with an avidity which, if "foolish," is certainly excusable, if nothing more. Nor can anything else be expected when such a sufferer so painfully remembers that in his great and anxious need he has been time after time to a "regular" physician, only to have the real significance of his mental distress misapprehended, or to have it characterized as "silly," or "imaginary," or "not for me," or of "no consequence whatever," or, as was the case with Lady Macbeth's physician, to hear him affirm that therein the sufferer "must cure herself"; or, perhaps worse still, to be treated by heartless "bluff," placebos, or possibly by hints of a normal defection that needs a priest rather than a physician! Nor, again, can anything better be expected, when possibly in obedience to this same distracting hint, such a sufferer has sought his church, only, as it has seemed to him, to be fed with stones, to be treated with indifference, or to be poisoned with doubts and insincerity, to say nothing of the chill that so naturally comes from sham brotherliness, untrustworthy sisterliness, and all the pain that these mean to the hungry distressed soul. If in such a case the "unorthodox" either in medicine or religion can "make good" where the "orthodox" fails, let there not be unseemly surprise, or charges of foolishness or worse, against those who in spite of such neglect and misunderstanding actually do need relief and must seek relief, even until they find it. Instead, let there prevail everywhere the full measure of righteous humility which is so often really due in the premises. The great "irregular" of all time, it must be remembered, was Jesus of Nazareth; and it was He who is said to have healed the people up and down the whole land, in spite of the "regular" doctors, medical and ecclesiastical, of the time. Of course, this is no tribute to quackery as such, either within or without the "professions"; it simply teaches that any one who would really do right in this important field must by every possible endowment and preparation be first and fully possessed, not only of the proper spirit, the needed sympathy, the untiring determination to understand the actual need and provide the real remedy, but additionally, of the most perfect knowledge of human nature and all its woes that can be obtained by patient, skillful investigation, and by most rational induction from well-authenticated facts. Mere one-sided, incompetent, or vain "irregularity" does not by itself suffice, any more than mere self-sufficient or negligent "regularity." In either case, the deeper the insight, the wider the comprehension, the truer the knowledge, the more direct the skill, the better the results achieved.

When the rightly endowed, fully prepared ministrant to a mind

diseased has once been given a case of mental suffering in hand—one whose investigations have led him as accurately as possible to differentiate it from the truly alienated cases that can only be cared for in protective institutions—he is at once often confronted with conditions that tax his insight perseverance and skill, not only to an almost unwonted degree, but far beyond the comprehension and consequently the sympathy of his employers. Frequently, also, he has to contend with varied and numerous and unexpected misleadings and coverings up of facts which may be mostly owing to a previous false diagnosis; or, he finds the patient's normal ideation more or less in a state of irrecoverable atrophy or decay; or, that there is perverted emotionalism quite beyond understanding and of a continuously disastrous nature; or that the will power has been so frequently strained and wrongly directed that it can be relied upon for scarcely any good effort at all; or, so frequently, all these in most perplexing combination. In fact, the case is always one where the whole organism is more or less under the spell of the mental distress, and consequently has a minimum of recuperative forces at command. Even almost every physical function is apt to be so lowered and perverted that, in turn, they may contribute to the disease of mind and to the resistance to be overcome. In fact, the case is one of "sickness all through"; and the remedy and management must be based upon this comprehensive vision, or failure will almost inevitably result.

Hence the wise remedialist will never neglect to at once institute *every* sort of hygienic, sanitary and therapeutic measure, which may be rationally indicated. Failure here is folly unmitigated; and no assumed "special" or "exceptional" ability that presumes to get along without due attention to the physical as well as mental functioning can make it otherwise, try and promise as one may.

Having first, then, given due consideration to the conditions and needs of the *entire case,* the wise ministrant to the mind diseased will next, and at once, seek to understand in detail the changes from the normal psychology which are the immediate sources of the distress. Here, again, ability to *investigate* with a penetration and thoroughness that only the trained scientist can comprehend is the next great duty which he owes both to his patient and to himself. To accomplish this, he will bring all that his life, his reading, his special training and experience have taught him; will exercise all the mental and moral qualities of which he is possessed; will devote himself in every manner practicable, not only to relieving the present distress, but to arousing such latent and stifled mental functions as will in due season contribute of themselves to help to overcome that which is abnormal, and substitute normal thoughts and feelings in its stead. In all this he will need and should have the full confidence and intelligent help of those who are

related to or responsible for the one afflicted. On the contrary, every attempt on the part of these latter to assume or restrict his proper functions, or to cover up that which should be told, or to interpose with their own cross purposes and perverting schemes, will only serve to embarrass him, and to hinder his patient's recovery. This needs to be said everywhere and repeatedly; for it has not even yet come to pass that such a necessary harmony of opinion and action is always to be relied upon. In general, it should always be remembered that the problem presented by instances of a mind diseased is really so complex, and often so unresolvable at best, that the intuitions, the careful watching, the knowledge and the devoted skill of every one concerned, are none too much for obtaining the best possible results.

With respect to all the "newer" and promisingly better *methods* of management of a mind diseased, with respect to its own especial needs—those that have been devised by more recent investigators—it may be said, in a word, that they all seek to be based upon strictly scientific methods, and so to become more and more reliable and eventually trustworthy to an extent heretofore unknown. The first thing one notes is that it seems settled beyond question that in all these cases there shall be secured at once a most complete and searching, yet of course judicious, "scientific confession," or more properly scientific riddance through confession, of all the deeply hidden harmful feelings, thoughts and habits, that so often are really the basis of the painful mental superstructure which has supervened. In almost all this class of sufferers some such kind of revealing of the underlying sinful, or shocking, or stressful life, is found to be the best method of preparing the way for the subsequent, constructive measures which may then seem necessary. Hence, for this purpose, much attention is now given, for instance, to invoking the recollection of all the startling and harassing dreams which so often give darkness and pain to the easily impressed mind, and then to their true interpretation as affecting the waking life. Likewise, even though it be through hypnotic and allied means, it is often sought thoroughly to recall and expunge from the uttermost depths of being any and every other sort of earlier experience, whether these may have been sinful, accidentally shocking, or freighted with some kind of awful stress, in order that the sufferer shall no longer remain the unconscious victim of these "subliminal," most vicious enemies, as sorely as before. In fact, the "new method" implies that most of these cases have, to begin with, profound need of what may well be termed a "drastic psychical catharsis"; and considerable experience shows that, once having secured this, such people are, at least for the time being, very apt to be relieved from their pain, begin to be noticeably ambitious and vigorous, beget new hopes and enter-

prises, and otherwise to astonish both their friends and themselves with unexpectedly rapid, at least temporary, improvement.

But it must always be remembered that even the most intelligent use of even this most scientific initiatory method does not often serve other than as a very serviceable prerequisite to imperatively needed subsequent measures, whose main object should be, not only as thoroughly to fill the vacancy thus made by evulsion of the destructive evil as possible, but also to put something more constructive and permanent in its place. Closely investigated, the human mental activities seem largely to be built upon a system of self-mimicries ("auto-mimesis"), which fact may often be very wisely taken advantage of in dealing with its abnormalities, especially of the curable order. If through some untoward experience or constitutional "predisposition," a painful and dangerous "copy" has some time been deeply set in the mind, and subsequently this has got into the vicious habit of being reproduced in endless repetition, and so beyond self-correction, not only has this important fact a most imperative need to be duly noted, and considered, and acted upon, from first to last, but also has the equally important fact, that almost every remediable instance of a mind diseased actually has this peculiarity, and attention to this may often reveal the right clue as to what will eventually do the most good and do it most promptly and permanently.

Remembering these facts, then, it is soon found that in very many cases indeed the most practical thing to do, after the preliminary mental cleansing has been effected, is at once almost obtrusively to proceed to introduce into the sufferer's mind a greater or less number of most definite, clear, interest-laden, moving, and if possible unusual ideas, which, being by the sufferer supposed to emanate from the mind of some one whom he looks upon as more of an authority than he is capable of being by and for himself, will be allowed to make their way unhindered, so deeply as to become an efficient counter-effecting force, and thus bring about the thoroughly neutralizing and substitutive effect required. In this way, a new copy, which is at once characterized, both by fresh interest and constructive imagery, may be so powerfully and timely, and likewise so aptly, repeated, that duly the mind will almost unconsciously begin to imitate this instead of the old copy, and thus in time will become both successfully refurnished and reinvigorated, and consequently relieved, as well. Undoubtedly such a course, especially if unremittingly enlarged upon and enriched by all such determined, luxurious effort on the part of the sufferers themselves, as will perpetuate the original effect, even until such time as their dried-up mental soil shall be made once more to teem as it should with spring-like rejuvenescence of every old activity, as well as with the germination and growth of as many new interests as possible—undoubtedly such a course

will succeed where many another may fail. In this there will often be surprisingly exemplified the fact that it is the inner, emotional and intellectual life, rather than the outer physical life, which pulls men and women down, as well as keeps them up; and that in connection with a decided change in the character and direction of these there may always be expected, whenever possible, a corresponding constructive response to whatever change in environmental conditions may be considered useful, in addition.

Having thus made a right beginning and got well on the road to practical success, it is simply wonderful what a capable, intelligent, wholesome "minister to a mind diseased" can thus do, for many of these cases, where there is such a malign and persisting interference with the life of all the affective as well as effective faculties of the sick-soul, as is here to be found. Like the gentle dew from heaven is his mere coming and presence often; often, too, like a strong tower of defense and offense, is the "presence" he leaves behind; like a veritable "new birth," does it soon amount to; like a complete regeneration in the end, in many instances.

Of course, it might be naturally supposed that the first and surest step toward securing recovery, especially from the woes peculiar to the misfit, would be simply to get them out of their inappropriate environment and wrong calling into a place and work more suitable for their endowment and preparation. And so it would be and is, in a comparatively few or perhaps many cases. But with the rest it is almost universally the fact that for so long a time have they been bred and trained in the midst of unrealization and unsatisfaction and consequently of rebellion and despair, and not less important in the direction of atrophy and negation of powers, that even when their outward circumstances have once been most wisely mended they do not respond nearly so constructively as might naturally be expected. Mostly, such people need a change of life within before they can satisfactorily appreciate and constructively respond to a change of life without. Until this change is accomplished—until the intellect and emotions and expectancies have been given at least a new direction—outer changes are much more likely, particularly in adults, to result in some or all of the unexpected disappointments which every other kind of unwise experimentation is everywhere so apt to see.

Having, then, as thoroughly cleared the sufferer's mind of every affecting and destructive idea and feeling as possible, and skillfully filled it with certain other ideas and feelings, which should be selected entirely for their own constructive, curative and inspiring qualities, it follows with equal necessity that the good work should not stop here, by any means, but rather should be supplemented unremittingly by most persistent use of every such well-selected, strong, wholesome, com-

prehensive measure, such as change of environment, work, study, reading, etc., as will naturally effect, step by step, the completion and fixity of the mental and emotional reorganization so obviously needed. For, no matter how effective the initial catharsis and substitution may be, if the remedialist does not know enough or has not spirit enough to follow up this concededly important ministry by subsequent adaptive effort, persisted in until the end is attained, his labor will be mostly in vain. Here it is, undoubtedly, that so many of the "practitioners" of the various systems of "transcendental medicine," pseudo-science, rampant humbuggery, "queer" theology, and vicious imposition generally, are not able to secure the permanent results predicted of them from their temporary success. Many of these can give and often do give a good enough start toward relief to warrant the confidence which such a course engenders; but they break down entirely as soon as anything additional is required, and so, either lose their influence at once, or else are forced, by maintaining a series of illusions which in time fatefully show themselves to be such, to continue to doggedly sustain some other sort of equally temporary measure, if not base imposition, which deservedly brings its dire reward upon their heads in the end. In these cases a single measure or practise of any kind, no matter how good or true, when persistently inculcated or exercised without timely and appropriate variation or addition, soon comes to the end of its chief usefulness; for the nature of the human mental and nervous organization predetermines that atrophy and decay in the realm of feeling and willing just as surely follow closely upon the over-exercise which produces an initial hypertrophy, as it does similarly in the physical realm. But the ignorant or indifferent practitioner does not consider this; and so pushes on unvaryingly with his initiatory measures only, or with others of similar or greater misleading import, and consequently finds that the original condition of his patient often comes to have duly added thereto, certain other abnormalities, which, although newly acquired, may yet prove to be not less distressing or less persistent than the original ones. So trite an injunction, then, as "Overcome evil with good" when applied to the needs of a mind diseased, is thus seen to necessitate a *right kind of persistent overcoming,* wherein the void repeatedly secured by eliminating the evil is continuously filled with restorative "good," the strength gained from time to time is constructively exercised, and all the psychic pathological conditions are thus led or made to give way eventually to normal states and activities.

Perhaps this is quite sufficient to enable us to conclude, finally, that permanent satisfactory results in this important field of remedial ministry can seldom be secured, unless due attention be given, first, to getting at the real sources of the sufferer's breakdown; second, to correcting, contributing and hindering physical diseases; third, to purging

offending mental imagery, and eliminating the deeper origins of pathological fears and distrusts and consequent exhaustion and pain; fourth, to making, and from time to time, remaking, as profoundly constructive impressions as possible; and, fifth, to reeducating and repractising every mental and emotional factor in such a sure way that eventually comprehensive reorganization is permanently effected, and the deeper, truer self is made to regain its normal attitude towards the world in which it finds itself, as well as the strength and habitual new activities which will enable it to maintain itself against subsequent insult and stress—in fact until the mind is once more as full of *ease,* as it was at the beginning full of *dis*-ease.

THE POSITION OF WOMEN IN CHINA

By Dr. L. Pearl Boggs

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SOME sage has said "A nation stands as high as its women." In making up an estimate of China at a time when she is earnestly desiring recognition as a republic, it may not be out of place to consider the position of women with a view to judging the chances which the new government has for stability.

Every one is familiar with the story and the personality of the late Empress Dowager, who, for nearly half a century, swayed the destiny of China's 400,000,000 people at perhaps the most critical times in their country's history. It was during the first years of her regency that the formidable Taiping rebellion was finally put down, thus insuring the integrity of the empire from within. It was also during her term of power that China suffered many humiliating experiences at the hands of foreign countries, including Japan, but nevertheless China as an empire was left practically intact. During her last term of regency, the government committed itself to modern western education and to constitutional government. It was a powerful personality that could hold the empire to the old way when a vigorous young party was striving to uproot old customs and law, and in turn could bring the old conservative party to heel when the change to new ways was finally determined upon. This could not have happened where women have no rights, honor or privileges.

What the empress did in her exalted station, any strong woman can do in whatever station she may be born. We hear, therefore, of women occasionally becoming the head of a family or clan, for something of the old-style patriarchal family is the prevalent form in China and is composed of grandparents, married sons and their families, and perhaps also younger brothers or cousins. The three submissions of which one hears so much in the orient, means that a woman must submit to the authority of the head of the family, be he her father, husband or son. A woman does not usually become the head of a family unless she is the widow of the former head and she rises to this position only if she is the strongest personality by far in the group. The writer does happen to know a forceful young Chinese woman who is known all over the country side as "the Christian girl who runs a farm alone and is the head of a family." Before her, the grandmother had been the ruler of the clan and had been honored by the erection of a "pailow," or three stone arches, by order of the emperor.

But in the main it is due to her position as the mother and grandmother of sons that she is honored, and every Chinese woman prays

for the gift of male offspring as Hannah of old must have prayed for Samuel. In reading the legends, biographies and anecdotes of Chinese life, one is struck with the respect paid to the mother as well as with the love rendered her by her children. In the works of the two great sages, Confucius and Mencius, love, reverence and obedience are enjoined as the due of both parents. The funeral rights of both parents are to be duly celebrated, and the ancestral tablet of the mother is always placed by that of the father and reverence is given to both.

In the history of China we read of several great empresses and empress dowagers who added to the luster of the renowned people of Han. In the ancient Book of Poetry, which is one of the great classics of the world, many women are celebrated in song for their piety and virtue, their wifely devotion, or motherly tenderness. There is a book of memoirs of distinguished women written about 125 B.C. and I know of no other book in any language at that time dealing with the greatness and goodness of women. Likewise the first book on the education of women is said to have been written in this language about two centuries later by a celebrated poetess and historian, Pan Chao, who for her learning and piety was appointed preceptress of the empress and honored by the emperor with the title of the Great Lady Tsao. Thus we see that in olden times the women of this country held a relatively high position, perhaps as high as the women in any pre-Christian civilization ever held.

But there is a somewhat darker side to be shown, when we come to speak of the modern Chinese woman as other than a mother. The childless wife of a rich man, or one who has borne him no sons, lives in fear lest he will take other wives. The presence of secondary wives, for according to law it is impossible for a man to have more than one legal wife, does not make for harmony in the household, especially if they succeed in alienating the affections of the husband. Divorce of the first wife is almost unheard of, and as the greatest crime a man can commit is to bear no sons, the practise of polygamy is defended on the highest ethical and religious grounds. The secondary wife is said to have no legal standing, but her children are considered just as legitimate as those of the first wife, to whom indeed they are said to belong. We have to picture to ourselves conditions somewhat as shown in the Biblical story of the patriarch Jacob and his wives and their handmaidens.

If the lot of the first wife is not always enviable, one can imagine that the concubines are not exactly happy. They are expected to be obedient to the headwife who rules the inner apartments, or women's quarters. In some cases they are little more than high-class servants and are often drawn from a class of society lower than the husband. Sometimes they are secured at brothels where they have captured the fancy of a rich man by their beauty and accomplishments. In some

families, however, the wives are said to live in happiness and harmony, and it has been the writer's privilege to know a Chinese Christian lady who showed the greatest kindness to the wives whom her Confucian husband had brought home, although his conduct had almost broken her heart.

On the whole, Chinese women are raising their voices against polygamy, as are the modern educated young men. It is difficult to see how a radical change can be effected very rapidly without entailing great suffering on helpless women, for the organization of a government may be changed quickly, but not that of domestic life. With the greater education of women which will make them to a certain extent economically independent, and with the example of western life, which every year is making more impression on the people, we may confidently expect the ultimate decision of this oriental people will be in favor of monogamy. It is needless to say that Christianity will teach this, as the missionaries are committed to an uncompromising opposition to all secondary marriages.

As everywhere, perhaps, the great middle class are the happiest in their domestic relations. The husband is too poor to buy other wives and maintain them, so that a male child is often adopted, from the clan if possible, to carry on the ancestor worship and perpetuate the name. The wife among the very poor may be sold as a slave and the money taken to buy another wife. If left a widow without grown sons, she may be sold as a wife again by her husband's relatives before the grass has grown green on his grave. Nowadays, there is a law to prevent a woman's being sold against her will, but often among the poor there is no alternative.

But the burden of all China's poverty seems to me to rest most heavily on the young girl. As an infant, if there are too many mouths to feed, her life is snuffed out in its first hours. In times of poverty and stress of famine, the first resort is to sell the little girls. If not as a wife, then as a slave or concubine. It does not require much imagination to picture what a little slave girl may suffer if her owners are unkind and she is sold about from one to another. On the other hand, she may come into a good family and occupy a useful and honorable position. There is a law that no maid slave shall be denied the right of marriage, and if she is attractive it may be to one of the men of the family. If the little girl is sold as a child wife, her lot may be very unhappy, for her mother-in-law is likely to make her the drudge of the family, and her husband, if he feels any affection, is never supposed to interfere in her behalf, as that only makes matters worse. The birth of a son is the great alleviating factor, for then a woman has performed the chief function in life.

One is not to suppose that the evils here mentioned, such as infanticide and girl slavery, denote any particular cruelty of nature on the

part of the Chinese people. Nearly all nations at some time in their history have practised infanticide, and slavery has not long been banished from our midst. The factors which have combined to keep up these practises may be traced back perhaps to the religion of the country which is that of ancestor worship. To this is due the over-population of the country in part; to this is due the marked preference for male rather than female offspring, as it is only through the former that the ancestor worship may be maintained; to this is due the early child marriages and secondary marriages, both of which tend to crush the young girl. It is knowing these facts, which impell the thinking people of Christian lands to feel the burden of sending to non-Christian countries those apostles who shall preach a religion of the spirit which knows no distinction of sex, or class, or race. To the teaching of a spiritual religion must be added the teaching of modern science and economics, for the practical mind of the Chinese can sometimes be reached by scientific laws and cold statistics where prayer and preaching fail.

The life of the daughter of the rich is not so bad, aside from the suffering of that ridiculous and antiquated practise of footbinding. So far as I know, no explanation has ever been found of this cruel custom and, besides the real suffering which the child undergoes, the individual is maimed for life and suffers not only the inconvenience of crippled feet, but also in general health from lack of exercise. In some families the daughters are given a little education in books as well as music and embroidery and, since the desire for the modern learning is spreading, it is said that every palace and official residence in Peking is filled with girls and women anxious to learn and who are studying as best they can.

It is certainly true that the educated women of China are making a name and a place for themselves and are working hard to better the condition of women as a whole. A visitor to that country to-day will find Chinese women as the heads of hospitals and in some cases also conducting nurses' training schools. They are principals of large government or private schools for girls, and many of them are doing excellent work. A few young women have graduated from American colleges, but the majority of principals and teachers are the products of mission or government schools. The very wealthy of course have private tutors and some of the most zealous women in founding schools for girls have been from princely families.

The ladies in their homes are also working for reforms and thousands signed petitions sent to England protesting against the opium trade which that country forces on China. They are forming anti-cigarette leagues and holding meetings at which some of them preside and speak with great intelligence and dignity. They are zealous in the anti-footbinding societies and take an active part in church and phil-

anthropic work if they are Christians. Nor should one forget to speak of the women in the church who go about as teachers of the Bible or on errands of mercy to the poor and suffering. Some of these are ladies of fine families and great learning, while others are poor country women, whose chief qualifications are a tender heart and a sympathetic mind rather than literary attainments.

During the late revolution the women bore no inconsiderable part. They were active in plotting and many women dedicated their fortunes and their lives to the dangerous work of propagating revolutionary doctrines or smuggling in arms from foreign countries. Young women everywhere were determined to enlist as soldiers, and in a few places "Amazon corps" were formed. Many others offered their services as nurses and the trained nurses and Bible women are said to have done effective work. Public meetings were held in all the large cities at which women spoke in behalf of the revolution, and wealthy women pledged their jewels to raise the much needed funds.

One of the most hopeful signs of all is the fact that the government promises to provide educational advantages for all girls in the same schools with the little boys until the age of ten, and afterwards by a separate system which is to end for the present in a higher normal school for girls. There seems to be a really awakened conscience on the matter of the education of women and there is something pathetic in the pleas which the educated young men of China are making that their wives and sisters may be educated. With their modern education, they are beginning to realize what it means to a man to have an uneducated woman for a wife or as the mother of their children. They are not ambitious therefore for an education which shall fit women for public positions so much as for good home makers. They realize that in China's present condition woman's greatest work lies in establishing new ideals of home life.

China has always been a moral rather than a religious nation, which means that the family rather than the individual sense has been developed. This may militate against the rapid growth of freedom for women in public life, but in the end will give her a secure and honored position. Perhaps the greatest problem in that country at present is the struggle which is on between family loyalty and individualism. It is hoped that this agitation will not so shake the moral foundations of the people that it will bring on a demoralization before it has had time to adjust itself to that broad socialism which is founded on individualism rather than is opposed to it. In the trying time that is coming, we believe that the women may hold the power to regulate the pace of the change which is inevitable. For the women of China are strongly moral, and the power of women in moral things has been recognized by the Chinese. One writer says: "Purification of morals, from the time of creation until now, has always come from woman."

THE SOCIALIZATION OF THE COLLEGE

By Professor WALTER LIBBY

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THE expression socialization of the college is here used not to indicate a process to be set going at some time in the future, but to denote a development which can be observed in the history of institutions of higher learning and which educational leaders as the conscious guides of evolution may now further, direct, and render consistent with itself. A comparison of the Oxford clerk of the fourteenth century, ascetic, other-worldly, sententious, immersed in scholastic logic, with some of the alert, yet philosophical, public men produced by the English universities of to-day, shows the line that academic evolution has followed during the intervening centuries. On this continent these contrasted types of university man find their analogies in the Harvard man of the middle of the seventeenth century, a clergyman trained by the clergy for the clergy, and the Harvard man of the twentieth century, educated under more democratic and less clerical influences.

The tendency of colleges to change in adapting themselves to changed social conditions is obvious enough. At the same time it is generally admitted that through economic and other changes society is marked by greater and greater complexity. How must we shape the college curriculum, methods, administration, etc., in order that our graduates may prove themselves efficient in the complex social conditions of the present day? This is the problem whose solution we and all interested in the progress of higher education have to discover. To the settlement of this question as it presents itself at this time I wish to offer a slight contribution from the standpoint of the college professor of pedagogy.

In the first place, for an American college to adopt at this time the narrow curriculum that two centuries ago introduced the student to professional studies would be a reversion dictated by despair. Fundamental as Latin, Greek and mathematics are to our civilization, our culture, our science, they do not of themselves afford an adequate preparation for life under modern conditions. Helpful as Latin and Greek are to our esthetic appreciation and sense of ethical values, filled with illumination and bristling with suggestions as are the ancient literatures, they could not mean so much for us had our minds not been formed and informed by other studies. Even as a step toward the dif-

ferentiation of colleges the adoption of the old curriculum would seem unwise, for the preparation needed for professional study to-day is quite other than it was in the seventeenth century.

One change entailed in the college curriculum by the growing complexity of modern social conditions is some recognition in the courses of instruction of those conditions themselves. In a democratic country we should all know how the other half lives. Social problems and needs must be learned. I wish to emphasize the truth that if they are to be known they must be taught. People who appear callous and cruel, indifferent to private needs and public welfare, are often merely uninformed. That the undergraduate years offer the opportunity for the presentation of such matter there is sufficient evidence.

During the last few years my department has taken up with the students in pedagogy the educational aspects of the university settlement, child-labor legislation, juvenile crime, the home, defectives, primitive peoples, eugenics, morals and hygiene, the immigrant, the new schools, open-air schools, etc. The work is conducted in seminar style, each student choosing a topic for intensive treatment. The response to these subjects from juniors, seniors and graduates is very cordial and very immediate. They cover, if you like, the romantic and sentimental phases of social activity, and the appeal is no less powerful on that account. On the other hand, there is no attempt on my part to suppress a discussion of the futility of some forms of philanthropy. I think the ultimate effect of such a course is to give content to the idea of good citizenship, to check latent snobbishness, and to increase a sense of the sanity and worth of the ordinary daily activities, especially the activities of the teaching profession.

There are other approaches to this same end, of which our professors are availing themselves. Courses in ethics are being given in many of the American colleges with excellent effects, and in these courses particular pains are taken to study the relation of the college to the complex social conditions in which we live. The teacher of ethics has the advantage that he can treat with authority the question of moral standards, such as the relative claims of benevolence and justice, trained, hard-headed thinking on which is one of the present needs of the democracy. But from what particular department the advocacy of the social claim comes, is a matter of indifference so long as it comes with conviction and force. History, sociology, economics, ethics, pedagogy, English, other modern languages, Latin and Greek in a marked degree, as I have implied, offer the mature mind an opportunity of broadening the social sympathy and deepening the moral consciousness of the students. It is impossible, without going into the details of class work, to indicate fully the intimate, subjective value to character of the quiet presentation of social facts. We are enlisting the interest, the thought,

the sympathy and ultimately the activity of the students in the cause of social progress and public welfare. That the students recognize and cordially respond to the changing tone of college instruction many gratifying signs indicate. The excellent article in the number of *The Atlantic Monthly* for November, 1911, on "The College: an Undergraduate View" saves me from the need of bearing further testimony on this point. If I might state the educational problem of the college instructor as it here presents itself to my mind, I should say: How can the esthetic appreciations of adolescents be transformed into the ethical judgments of the manly and womanly mind?

Naturally, in a really educational process such as I am briefly outlining the personality and ideals of the instructor must play a large part, and the change in the social efficiency of the college toward which some of us are groping our way seems to imply a shifting in the conception of academic culture. It is difficult to arraign any type of culture, and almost ungrateful to imply that the eighteenth-century idea that the finest type was secured by reading a little good poetry, hearing some good music and speaking just a few words of sense daily is from our present point of view untenable. A comparison of two Oxford men of the nineteenth century, Lewis Carroll and T. H. Green, will help me in my statement. Lewis Carroll was a thoroughly cultured gentleman, presentable in the best society, a delightful companion, an ingenious writer, whose pages have delighted thousands in need of innocent entertainment. In addition he was for long years a college instructor and a contributor to the literature of mathematics. Green was a man of different stamp. He lacked something of the grace and charm of Lewis Carroll. He was less popularly known, but no less socially important. His contributions to the literature of philosophy were weighty. He was the leader of a great movement in the history of the thought of our race. He exerted an immense influence on the minds and conduct of the college men with whom he came in contact. Through Mrs. Humphry Ward's presentation of him as the Mr. Grey of "Robert Elsmere," he gained recognition with the reading public as one of the great forces in modern social progress. Lewis Carroll was extremely conservative, opposed to the rights of women, complacent about children's acting on the stage, hostile to the advance of science study at the university. Green succeeded in the conciliation of town and gown, became a member of the municipal council, was instrumental in establishing a local secondary school, and had his university duties permitted it, might have become representative of the city in the councils of the nation. He extended his sympathy to the cause of human liberty beyond the sea, and received the news of Gettysburg and Vicksburg with the enthusiasm becoming a large man. Can we not say that he represents a type of culture as worthy as any, and increasingly de-

sirable in the colleges of a democratic country and race? The changed conception of culture I have tried here to indicate as increasingly characteristic of the academic mind must impress college students with the reality, the robustness, of our ethical aims, and make of great educational value any instructor, no matter in what department, who holds and embodies it.

When young people leave college halls with dreams of the betterment of the human race, they should in the first place make sure that they do not prove a burden to their own families. An up-to-date, democratic culture should not interfere with their earning their own living. In fact, if properly educated, they will see in the choice of a calling a question of the greatest moral moment. To fit oneself for a vocation, to adapt oneself in a business way to society, is not hostile to true culture. It is in recognizing the real bearings of our daily task, and taking satisfaction in it that we grow into the only culture that seems worth while to the adult mind. Is it too much to say that one of the dangers of our age is the dilettante pursuit of scraps of the arts, and crumbs of the foreign languages? In the years of maturity the cultivation of these interests has something of the pathos of arrested development recurring to the styles and ideals of the teens.

The change in the attitude of professors and students towards the needs of the people and the welfare and progress of society, so intimately educational in its nature, seems to me the most promising factor in the movement for college and university reform. As a professor of pedagogy I would here lay the chief emphasis; but this change in the conception of academic culture implies further changes to which I must hasten.

Space does not permit me to speak of all that American colleges are doing, all that is still left them to do, in laying the cultural foundation, as I understand the term, for the learned and other professions. If our doctors were all true guardians of the public health, if all our engineers were bent on furthering hygienic conditions, if all lawyers were zealous in the cause of social justice, if all clergymen appreciated the larger aspects of the people's needs, the cause of human welfare would be secure. I must pause a moment, however, to say something concerning the relation of the college to the schools.

In the American college that I know most intimately about four hundred students are received annually from the secondary schools and other colleges. About one hundred and fifty are graduated every June. Of the graduates, seventy or seventy-five return as teachers to the schools. The secondary school affords the college, therefore, one of its most important points of social contact. It is largely through the high schools and academies, which in turn influence the grades, that the college makes its culture tell on the lives of the poor and common people,

from whom the majority of us are sprung. If we seek an aim, and are not blinded by academic pride, here is one right at hand. You will not be surprised to hear that the policy of the modern department of pedagogy is to help, not to exploit, the high school. The social point of view is capable, perhaps to a greater degree than one might at first expect, of modifying our procedure in dealing with the lower schools. The chief function of a college department of pedagogy is to turn out well-prepared teachers, enthusiastic, and with the right attitude toward their work. It should not, in my judgment, lend itself to cheap advertising, or drumming up students, or making a hit with the high schools and academies. Those imbued with the social spirit will find the hundred problems of adjustment of the college to the secondary schools too vital to be dealt with in a narrow or commercial spirit.

The relation of the college to the rich is no less important than the question just discussed, if the college is to preserve the right tone towards the social needs and aspirations of the whole people. The history of European universities shows that these institutions have been used to further the political views of their founders. In France and Germany, for example, universities have been used almost like fortresses to hold territory gained in war, as can be shown by reference to Breslau, Strasburg, Bonn, Bordeaux, Caen and Poitiers. The numerous universities organized by Napoleon were designed to carry out his policy of government. In view of this background afforded by history one can not be indifferent to the influence of founders and patrons upon their universities. Just how the millionaire founder or the millionaire trustee affects the social relations of the college calls for more extended statement than space here permits. In a few glaring instances in this country there have been serious infringements by the wealthy supporters of a university upon the spirt of academic freedom. But the predominance of the rich in the councils of the college has acted more insidiously in the social ideals that they perhaps unconsciously put upon the institution. One might mention briefly the expenditure of money from the business standpoint of the advertiser rather than from the educational standpoint of the professor; the treatment of the instructors as employees rather than as a body of self-respecting gentlemen working in a great social cause; and finally, the character of the officers likely to be chosen by trustees filled with a commercial rather than an academic spirit. A glance at the constitutions and administration of the universities in monarchical Europe as compared with these features of American universities causes no small wonder that in this country institutions of higher learning are comparatively aristocratic, not to say autocratic. The University of Oxford, for example, is governed by three bodies, council, congregation and convocation. The first, council, is made up of six heads of colleges, six leading professors, and six

representatives of the alumni. This is the cabinet of the academic state. The second, congregation, consists ideally of the teaching force of the university. It has important legislative powers. Convocation is made up of the M.A. alumni who have maintained close relations with their alma mater. This body chooses the chancellor of the university, exercises the right of veto, elects members of Parliament. Even this scheme is now undergoing reform along even more democratic lines. How far behind we are, with many of our colleges and universities governed by a secret conclave of wealthy men and a president not responsible to the teaching force or to the alumni!

To prepare citizens for a democracy the organization of the college itself must be democratic. If it be true that we learn to do by doing, the student should learn at college to be a citizen of a free state, not alone by precepts or academic instruction, but by the experience of membership in a free college community. Wherever there is an absence of social aim and organization on the part of college officers it is little wonder that the student body is lacking in purpose and does not rise above a community consciousness of a very primitive sort. With the colleges filled with the right social spirit the students feel themselves the members of a great republic of letters, or rather, of a democracy of science, possessed of a truth too vital to be merely individual and academic. The utilization of the ethical and social life of the school as a means of moral education, which, since Arnold's day, has been a recognized feature of the great English public schools, where, as Haldane remarks, English boys are permitted and encouraged to govern one another, is still almost unknown in some of the American colleges. If the president and the professors take the students into their confidence in the discussion of general aims as regards the welfare and progress of the people, then the corporate life of the school can be organized on a higher basis, discipline becomes more and more self-discipline, and anti-social types feel themselves condemned by the judgment of their peers in academic standing.

A measure of the change for want of which many American institutions of higher learning are suffering to-day was wrought out in the German universities by Fichte and others over one hundred years ago. It can be described briefly as a greater measure of freedom, spontaneity, self-activity. One should not, however, forget that increased freedom must mean an increased sense of responsibility and that self-activity must be activity of social import under social stimulation. When the members of the college understand their true social end and aim, athletics will occupy a more subsidiary place, and our institutions of higher learning will be more than mere clubs for wealthy young men. It is only in the absence of the enunciation of serious purposes that the college shows the tendency to triviality and puerility of which some

complain. The youngest freshman knows that success on the athletic field is not the chief end of man, and he is quick to note the falsetto in the football enthusiasm of the middle-aged and elderly professors when they pretend that the scores of the teams are the chief topic of academic interest.

Lack of appreciation of the educational value of college organization has blinded some educators to the merits of college fraternities. These organizations have a long and interesting history which can be traced back to the medieval nations at Bologna, Paris and the other early European universities. At present the college officer is likely to regard them rather as an administrative danger than as an educational opportunity. In our present system the fraternities are in effect if not in fact the vestigial remains of a university constitution in which the student body and the alumni played a vastly more important part than they do with us. A revival of academic freedom would restore the fraternities to their healthy functions. Now, as Birdseye and others too plainly show, a college fraternity, like other rudimentary organs, is liable under unfavorable conditions to deterioration and disease.

Again, if the students and the college in general with a fuller measure of academic freedom and an increased sense of their social responsibility would reconsider the curriculum and methods of instruction in the light of democratic principles, many wholesome changes could be brought about.

Besides instruction in sociology and the social aspects of pedagogy, economics, history, English and foreign literature already spoken of, I wish to mention here only one other subject, namely, physiology. Recent developments in natural science, above all, progress in bacteriology, have made the pursuit of this subject in college a pressing need. In addition to courses in scientific physiology we should have in every college popular courses on applied physiology for all the students, dealing with the vital questions of hygiene. Such courses are necessary for the guidance of the undergraduates in reference to diet, sleep, habits of study and of personal health in general. For, keeping our social purpose in view, it is not hard to see that one of the chief endeavors of the college should be to disseminate through the schools and in the homes the knowledge of hygienic science that is so necessary for the comfort and welfare of the people.

The social test of college culture would suggest many changes in the content and method of other college courses. The spirit of pedantry, to which all academic life is liable at times to fall victim, would be rectified by the challenge: "What is the social value and import of this?" If every college course were in its content socially important, then the students taking part would work more spontaneously, and the present methods of dictation and exact prescription would give way to greater

activity and initiative on the part of the student and greater freshness of response and cooperation in general.

The best methods, however, and the best results from college work can only be obtained when all college students and professors are engaged on some real, useful work instead of busying themselves with mere exercises. The tragedy of college life as seen by the up-to-date educator is that we in many cases are attempting to train for life activity by a series of exercises that can be regarded only as remote approximations to actual activities. This fault shows not merely in the college of liberal arts, but, where one would least expect it, in professional, and in spite of the rapid introduction of practical work, even in many engineering schools. In four or five years the engineering school as a rule does not undertake to teach engineering, but only to give preliminary exercise work to form in the future the basis for acquiring the profession of engineer. The remoteness of academic training from the real goal to be attained is naturally more marked in the other departments. One phase of this weakness is found in the endless theme work produced by students in compulsory English composition. As has been wittily said, there is a great difference between having something to say and having to say something, and in the work of composition the student is, indeed, placed in a notoriously artificial attitude. This serves here, however, merely as an illustration of a general defect observed in college work, which in the opinion of the writer results from our failure to demand for our work a social aim and purpose. How to provide real work and real activities for a thousand students on the college campus is a matter calling for some exercise of ingenuity. I must content myself with a single illustration of the work that might engage the scholarly activities of our undergraduates. The need of good translations of French, German, Italian, Spanish and other scientific works, our college and university men will readily join with me in recognizing. With, let us say, five hundred students in French, six hundred in German and a proportionate number in the other foreign languages, something of social value could surely be done in this matter under the direction of capable instructors. The translation last semester by eleven students in one of my classes of a complete French book of over three hundred pages opens up a vista of possibilities of real cooperative work of public importance.

If we held consistently to a distinct social purpose, most of the valid criticisms one hears of the college would be met. One of the severest critics of higher schooling of all sorts complains especially of the lack of effort at moral improvement. He emphasizes the futility of the college in helping the young man of limited means in the fundamental social matter of earning his own living. Others join him in pointing out the tendency of some of the colleges to become mere play-

grounds for the leisure classes. Many critics within and without the college comment on the lack of serious purpose among the students, the failure of the heads of colleges to formulate for their institutions a definite aim and program. Others concentrate their attention on administrative questions, the lack of responsibility of the trustees, the helplessness of the faculties, the autocracy of the president. Finally, it is admitted by an eminent educational authority that a fair equivalent of a college training can be gained through correspondence or even a brief course of reading. Such pessimistic comment falls away from a college or university animated by such social spirit as I have sought here to indicate and advocate. Such a spirit will entail not a narrow, but a broad curriculum to answer the needs of an increasingly complex civilization, and a more liberal discipline with more guidance, and less repression, more freedom and an increased sense of responsibility, in order to fit for citizenship in an enlightened and self-disciplined democracy. Great changes in administration are inevitable, an autocratic university is incompatible in a free democracy, but the essential change needed is an educational rather than an administrative one.

The typical American college has been necesarily denominational to maintain the doctrines and faith that to its constituency seemed vital. In the present great diversity of belief many of the colleges show little or no sectarian bias. Unless these institutions are, with increased liberalism, to be marked by laxity of principle, and flabbiness of moral purpose, they must gain a new motivation worthy of the times, they must work under the inspiration that a hope and faith in human progress gives. To show how the minds of students can be affected educationally so that the college may be touched with this spirit of modern democratic culture is the main purpose of these pages.

In conclusion we may say that the change we seek to further in harmony with an evolution already under way is designed to make the college responsive to the social need of the present, to render it more publicly significant, possibly less denominational, certainly not less religious. In a word, one might say, more democratic and less sectarian.

MODERN SCIENTIFIC THOUGHT AND ITS INFLUENCE ON PHILOSOPHY

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I

TO enter upon a discussion of the influence of modern scientific thought upon philosophy is to find one's self beset by temptations to a discursiveness not possible within the given conditions of time and space. Under such pressure, one might be led easily into a consideration of relative values—efficacy of methods, seriousness of limitations, ultimate soundness of criteria, the final significance of present tendencies. As I write, however, these problems seem so turgid with potential misunderstanding as to embarrass rather than facilitate the discussion that, as a student of biology, I had planned. To avoid such embarrassments, attention will be focused on the general theme through an examination into the nature of scientific truth. This procedure not only will put into my hands an instrument whose uses are relatively familiar to me, but will serve, I believe, to illuminate some of the most significant phases of modern philosophic thought.

Poincaré has somewhere made a suggestive comparison between the Gallic and Anglo-Saxon genius. Characteristic of the one is a feeling for form, for symmetry, for logical completeness, for finality; characteristic of the other is a feeling for substance, development, function, change. For the one, truth lies in the result; for the other, in the process. One is represented by a deductive, the other by an inductive type of mind.

I have no desire to raise here a national issue. Whatever the merit of this characterization of these ethnic groups, it will serve my purpose if it give vividness to the statement that the same general differences distinguish certain philosophers and scientific investigators. Wherever one finds a faith in final causes, a hope in the revelation of ultimate truth, there one finds a philosopher who, like the Frenchman of Poincaré, has drawn the essential elements of his inspiration from the philosophy characteristic of ancient Greece. Modern science may have supplied his convenience with the telephone and the electric light, the automobile and the thoroughbred, aniline dyes and serum therapy; but it has done little more. Until he views the truth as nothing final, as existing in

the process rather than in the result, as a growing, expanding, changing vision, blooming with youth as long as human life can use it, it can hardly be said that his eyes have felt the touch of the spirit of modern science.

Wherever modern science has affected characteristic changes in the trend of philosophic thought, the result has been achieved by lessening the influence of that ancient legacy which may be conveniently referred to as the doctrine of final causes.

It must not be inferred, however, that the influence of this doctrine has been confined to philosophy alone. It has been felt in every field of human inquiry that presents a speculative aspect, an opportunity to reach by means of the imagination into the unknown. The history of science is one long record of struggle between just those types of mind that Poincaré has sketched. In none of the sciences, however, has the conflict been more prolonged and bitter than in biology. There the fight has been waged about the four great problems of evolution, individual development, vitalism and adaptation. None more than these offer speculative opportunity—abundantly accepted. None more convincingly than these show the inexorable incompatibility of faith in final causes and scientific progress.

I present them, therefore, as my chief aids in developing, if I may, a fruitful conception of the nature of scientific truth. Having reached such a conception, we will proceed to discuss its relation to the philosophic thought of the day.

II

Faith in final causes is not a necessary product of a particular civilization, of civilization at all. Though it may persist in the midst of sophistication, it is born of inexperience. Under one form or another, it has existed among peoples of all sorts, wherever they have possessed sufficient intelligence to hazard an interpretation of their universe of experience. Of these peoples, the Greeks and Hebrews claim our especial attention, since it is from them that the main streams of our philosophy and science and religion flow.

Compared with the sophistication of Aristotle's theories of life, the cosmology of the Mosaic record is strikingly anthropomorphic and naïve. In spite of this naïveté, however, there is no question of its astounding control over the history of scientific thought; the more so, since it is to the second and far cruder story of the creation, in fact, in the second chapter of Genesis that the church chiefly pinned its faith in its long struggle with the doctrine of evolution. The struggle has been at times debased with bitterness and violence. One grows heartsick at the sad spectacle of a Galileo swearing away his scientific probity as he groveled in fear of torture before the Inquisition.

But it has not been through such violence alone that the influence of the Hebrew tradition has been felt. More subtly did it discourage the great anatomist, Vesalius, who, in the flower of his young manhood, filled with the spirit of the pioneer, linked his fortunes to the throne of Charles and Philip. It is significant that, while he idly fretted out his life on Spanish soil, Suarez, the Spanish Jesuit, was born, destined to create the doctrine of special creation in its modern form by reaffirming in detail the Mosaic account of the creation—even the episode of the rib. The fact carries a suggestion of the reason why the productive years of that great progressive in biological science were limited to five, and ended with his thirtieth anniversary.

It was against this anachronistic doctrine of special creation, crystallized out of the civilization of the seventeenth century, that Darwin launched his great argument in the shape of the "Origin of Species." But, in doing so, he found in his opponents Hebrew tradition mixed with Greek. Evolution was not a conception hostile to the mind of Aristotle, though what we now recognize as phenomena of evolution did not especially engage his attention. The two rather ambiguous passages in which he arranges living creation in a series of closely intergrading types might be interpreted in terms of evolution without doing essential violence to his general conception of life. The origin of species of organic beings was not with him an issue. He was unaffected by the Mosaic record. Historical problems were to him of less moment than essential relations of structure and function. His especial interest in the ultimate analysis of truth was not, however, incompatible with an admission of the transformation of organic types. Indeed, under the influence of Aristotelian philosophy, St. Augustine himself sought to interpret the Mosaic cosmology with its conception of an external Creator, in naturalistic terms that should harmonize with the Greek conception of forces and potentialities inherent in the universe itself. It is this mixed derivation that complicates to some extent attempts to trace to their origins the ideas of the modern world.

There was no fundamental incompatibility then, between Greek tradition and the doctrine of descent with modification. As an evolutionist, Aristotle was at least as modern as Charles Bonnet. Were he alive to-day, I should confidently look for him in the foremost ranks of biological thinkers. His biological contributions, however, have been largely obscured by his versatility of interest in final causes. This interest I am disposed to believe was a product of his time, of the age into which he was born, of his education, his companionships, rather than a fundamental tendency of his mind. However it may be interpreted, there is no doubt that his ideas on transformism in organic nature were definitely limited thereby. If he was an evolutionist, he was also a teleologist. Adaptation in nature spelled for him design.

Organic types might change, but in accordance with a perfecting principle that should lead finally to the crowning glory of the evolutionary series, the human species. Perfecting principles are not unknown—witness Lamarck and Nägeli—in the speculative biology of the last century. In the hands of no one, however, have they proved to be instruments by means of which discoveries are made. Their influence has been conspicuously negative.

It was essentially Aristotle's teleology that Darwin, as late as 1859, overmastered with the doctrine of natural selection. It was Aristotle's evolutionary series, ending with man, that, fashioned into the semblance of a pine tree by Lamarck, was finally displaced by Darwin's conception of a genealogical tree without a central axial trunk flowering at the tip in man, but branching polychotomously in all directions from a common center. This modern conception harmonizes with the fact that there is no evidence that man has been fashioned, whether by special act of an external creator as in the old Hebrew account, or by the less direct process of evolution under the guidance of a final principle inherent in nature, as in the Aristotelian tradition, to be the lord and highest product of organic creation.

The Hebrew tradition embodies too naïve a conception of final causes for the philosophic as for the scientific minds of to-day, although it still lingers in various forms of religious doctrines that typically compose themselves, as President Jordan has somewhere aptly remarked, out of the débris of our grandfathers' science. Aristotelian evolution still lingers, though negative and barren on the fertile soil of modern experience, in the minds of those who admit with Aristotle the evolution of the physical man, but view, with him, the mind as a thing apart. It is characteristic of a faith in final causes that it permits distinctions of this sort. To the average biologist, however, to admit the validity of the distinction would be to question the validity of organic evolution itself. For the evolution of the body is neither more nor less certain than the evolution of consciousness. Both, for the student of objective science, rest upon evidence of the same order.

It was to be expected that Aristotle, a pioneer in science, would overestimate the simplicity of his problem of creating order where order had not reigned before, that he would seek for final causes with a suggestion of the simple confidence of the woodsman who traces smoke to fire or hunts his quarry to its lair. He was, scientifically, of necessity unsophisticated.

It is on other grounds that we must seek an interpretation of the persistence of this phase of his influence in contemporary thought; a phase which I suspect he would now agree was the portion of his legacy least worthy of our regard. There is something foreign to the spirit of Aristotle, something savoring of a sophistication born of conflict he

could not have known, in the following passionate challenge of a modern defender of the faith in final causes:

"Let not science contrive its own destruction by venturing to lay profane hands, vain for explanation, on that sacred human nature which is its very spring and authorizing source." Modern developments in philosophy itself indicate that the challenger need have no fear. Whatever the inevitable expansion of human knowledge may accomplish for human nature will not be by means of violent or profane hands. Conceptions of human nature, like all other conceptions of the human mind, adapt themselves quietly, impersonally, without anguish, to successive discoveries of truth.

III

Passing now to the problem of development, one is struck by the modern aspect of Aristotle's contribution.

Have you ever seen an egg grow? Have you perhaps followed the frog's egg, as it splits up into a group of segments; seen a cleavage furrow spread across it, new furrows succeeding each other with every half hour; observed the segments rhythmically swell and flatten with each cleavage; felt the mystery of this marvelous plastic process of development? Here is life; here is activity. And the juxtaposition of these phrases is not accidental.

Aristotle knew nothing of the cleavage of the frog's egg. He had no knowledge of the segments thus formed—which are now called cells. He did not know that the egg, is a cell also, comparable with the cells that make up, as fundamental structural units, the various organs and tissues of the body; that the egg like these other cells, possesses a characteristic body called the nucleus, which, as in all nuclei, contains a substance (chromatin) now generally understood to be most intimately concerned with the phenomena of differentiation and heredity. He was ignorant, also, of the nature of the male sex element, vastly smaller than the egg and differing from it remarkably in form, being adapted to a life of great activity. Otherwise, he would have known that the sperm, like the egg, is, in spite of its size and form, a cell, furnished with a nucleus and chromatic substance. And had he lived as late as 1875, he might have known that the essential facts of fertilization consist not only in the stimulation, the activation of the egg by the single sperm which penetrates its substance, but in the fusion of the egg and sperm nuclei and the mixture of the chromatin thus derived from the two sexes.

Nothing of this Aristotle knew. But he had observed the development of the chick. Without the microscope he had failed to note the early stages one sees so readily in the frog. But he had seen the embryo gradually appear on the upper side of the inert yolk, and he had seen

the heart begin to beat on the third day of incubation. It all impressed him to an extent that led to a treatise on generation.

To account for what he saw, he conceived the egg—the female contribution—to be essentially passive, containing elements that could be wakened into life by the active principle of the male. This he conceived to be a sort of enzyme, a ferment, which acted upon the female germinal substance like rennet upon milk. From this simple beginning he believed the development to progress, organ following organ; and since the spermatic fluid, the active principle, was itself unorganized, he rejected the possibility that parts should preexist.

Crude as all this is, it was an approximation to the truth, based on the facts as Aristotle had observed them. To this extent, his theory of development has a modern look. On a second glance, however, one discovers signs of the same eagerness for final explanations that we have already observed in our discussion of the problem of evolution. How, from so simple a beginning, was the remarkable complexity of the adult structure to be differentiated? And how was the fact to be explained that chick eggs, when they develop, always produce chicks, turtle eggs turtles; that animals reproduce after their kind? These were problems that at once engaged his attention, and were answered with characteristic promptness and confidence. Though the germ may be substantially simple, it is subject to two transcendental potentialities that constrain its development with reference to *species* and *form*.

And here Aristotle lapses out of the company of objective scientists. To say that an egg reaches a certain form because it possesses the potentiality to reach that form, is like defining a word in terms of itself. It is hardly the type of interpretation to commend itself to modern investigators. Yet it has been the refuge of many minds throughout the ages, and in a more refined and subtle form is used to-day by the distinguished author of "The Science and Philosophy of the Organism," to mask the hopelessness in his retreat from the firing line of experimental biology.

It is the ugly function of final explanations, causes, elements, principles, in biology, to call a halt. Trust them and, like the genii of old, they whisk one swiftly out of the current of scientific thought. One ceases to ask questions that are amenable to objective tests. And science itself stagnates until such questions germinate again in the minds of men.

From Aristotle to Caspar Friedrich Wolff extend two thousand years barren of inspiration. Harvey, the famous author of the "Exercitation on the Motion of the Heart and Blood in Animals"; Malpighi, his great Italian contemporary; and the indefatigable Dutchman, Swammerdam, had each made serviceable observations on the development of mammals, birds and insects, but had contributed no new ideas. By the

middle of the eighteenth century, there had still been no advance upon Aristotle, but there had developed a sharp contrast between two theories of development. On the one hand, Wolff supported the Aristotelian theory—now dubbed, since Harvey, epigenesis. On the other, Charles Bonnet, Albrecht von Haller and others elaborated its direct opposite in their theory of preformation.

Again, in Wolff's restatement of it, epigenesis takes on a modern aspect. The parts follow each other in development, and each part is primarily an effect of another preceding part and thereupon becomes the cause of another part that succeeds it. This is essentially the modern doctrine that one stage of development is conditioned by the stage preceding it as it conditions the stage that follows. It is crowded with suggestions; that bear no fruit, however, for lack of knowledge, in Wolff's imagination. Just as Aristotle endowed the simple germ with controlling potentialities that had no objective existence, Wolff achieved the same differentiation of the homogeneous germ by means of a *vis essentialis,* that sent him sailing also through the airy altitudes of final causation.

Contrary to the belief of Wolff, Bonnet and Haller found it impossible, on philosophical grounds, to conceive the beginning of the parts of an individual. For them, the germ contained the whole preformed in every part. While Bonnet insisted that man's body was not made like a watch, of added parts, but existed from the beginning as a whole, Haller was emphasizing the absurdity of believing that such a complicated apparatus as the eye could be formed as the epigenesis of the day demanded, out of crude materials by mechanical forces. Malebranche brought forward the clever device of infinite divisibility to overcome the patent objection that ordinarily the parts, whether present or not in the germ, could not at first be seen. And Bonnet admitted the obvious qualification that the parts need not exist in just the same form in the germ as they possessed in the adult. For him they belonged in the germ to a sort of invisible meshwork.

To this theory of development which sought to substitute for Aristotelian entelechies and Wolffian essential forces the conception that differentiation merely consisted in the expansion, with a push here and a pull there, of a structurally preexisting whole, numerous objections arose both in logic and in objective fact. If an individual were preformed in the germ, all the offspring of that individual must be preformed in it also. Which meant that, encased in the body of Mother Eve, one within the other, were all the germs of all the individuals of possible future generations—a sufficiently grotesque result. Wolff himself contributed one of the most telling facts against it when he described the formation of the tubular gut of the chick by the folding

up of a flat layer of tissue on the yolk. Obviously in this case the gut did not exist as such in the germ.

It is unnecessary to multiply objections to this interesting bit of metaphysic. Both the epigenetic and the preformationist theories of the eighteenth century are dead and buried under the relentless logic of events. Essential forces and preformed miniatures, alike in their finality, were unable long to withhold the attention of naturalists from the more potent suggestions of a rapidly growing body of new observations.

With the discoveries that organisms are built up of morphologically equivalent protoplasmic units, or cells; that both egg and sperm are cells, also; that the nucleus, especially the chromatic substance, is the part of the cell chiefly if not wholly concerned with the inheritance of the individual and specific characters and their distribution in the developing organism; more than all, with the discovery of the essential nature of fertilization, new theories were devised to interpret the still puzzling problem of individual and specific differentiation. These, like their prototypes of the previous century, fall into two contrasting classes.

Both of these classes of theories recognize that individual differentiation can not be interpreted without regard to race development. The germ from which the individual springs has history behind it, is composed, indeed, of two fragments of two preexisting individuals, the parents, who, in turn, sprang similarly from a previous generation. It is at once apparent that all modern theories of development must reckon with these facts; which means that, however simple we may conceive a given germ to be, the probabilities are overwhelmingly opposed to the conception that it is homogeneous; and they are equally in favor of the conception that it possesses from the start, in view of its relation to a preexisting parent, some degree of differentiation.

In perfect accord with these requirements, modern epigenesis and modern preformation nevertheless exhibit characteristic differences. On the one hand, is the preformationist theory of determinants devised especially to explain the persistence, through many generations, of very trifling characters, such, for instance, as a small pit on a human ear, recognized as a family trait, or a spot on one surface of a butterfly's wing, or a lock of white hair on a particular area of an otherwise dark-haired head. Such characters appear to come and go without effecting in any way the other characters of the organism. This independent variability is interpreted on the assumption of fundamental living units in the chromatin of the germ nucleus that represent and determine all the various characters of every individual. The germ chromatin is accordingly conceived to contain the determinants of all the heritable characters; and these are further conceived to be so associated, that in the

course of development the determinants are parceled and reparceled by the repeated divisions of the nuclear chromatin, an element in the cleavage process that, we have seen, is so striking a phenomenon in development. Differentiation thus depends not upon the literal expansion of a preexisting whole, but upon the *distribution* of the preformed determinants in the germ that have been inherited from preexisting individuals. And this distribution takes place, by nuclear division, in such a way that the right determinant always finds itself ultimately in the right place, that is, in the same relative position that that sort of determinant occupied in the parent.

The germ, then, is not only the abiding place of an enormous and complex assemblage of determinants, but these determinants are living morphological units. Not only that. They struggle for existence, according to the conception, just as organisms do. The basis of this struggle lies in inequalities in the food distribution in the germ, whereby some determinants will obtain less nourishment and weaken correspondingly, while others will obtain more nourishment and correspondingly strengthen. As the determinants in the germ, so the organs, the characters which they determine, vary.

By means of this ingenious application of the theory of natural selection to the vital units of which living substance is composed, the determinant hypothesis obtains a theory of variation which at once distinguishes it from the preformation theory of Bonnet. It goes still farther. Even the biophors vary—those ultimate vital units of which the determinants are the first aggregates.

With this liberal provision for variation, the determinant hypothesis would appear to have approached very close to modern conceptions of epigenesis. Certain fundamental differences, however, still persist. Whatever the provision for variation in the germ, differentiation proceeds, according to the determinant hypothesis, by the segregation of determinants already present in the germ; and these determinants are *vital morphological units.* According to the most advanced epigenetic theory, differentiation proceeds from a relatively simple germinal organization, not by the segregation of hypothetical vital units, but by means of progressive changes of a physico-chemical nature.

Just here appears the characteristic of the determinant hypothesis most significant for us. While the great inventor of the determinants finds it fundamentally necessary to assume a structure for living substance that is based upon ultimate vital units that have individuality, grow and reproduce, various investigators are discovering no such necessity in the facts. What *is* necessary is a hypothesis that will work. One of the strongest objections to the determinant hypothesis is, that, paradoxically enough, the chief researches it has stimulated are those which have been guided by the assumption that it would *not* work.

One need not fail to appreciate its logical completeness, its symmetry, and the skill with which it has been defended, and yet one need not be blind to the fact that it has not been a stimulating guide for its friends. It has been conservative rather than progressive. Founded on a definite morphological conception of the ultimate constitution of living substance, it has not adapted itself plastically to the rapidly changing conditions in biological science. The considerable amendment it has received in the last eighteen years has only made it so cumbersome and complex that it is now little more than a mere formulation of the facts it attempts to explain.

Time will not permit us to explore thoroughly the mass of evidence on which this criticism has been based. While differentiation according to the determinant hypothesis assumes qualitative divisions of the chromatin in the nucleus, numerous investigations have shown that at least five divisions of the egg in some animals may occur before there is any recognizable difference between the cells thus formed. Each of the first sixteen is competent to develop the entire adult structure. The only way to account for such a result in terms of morphological determinants is to assume that a complete outfit passes to each cell with each division of the nucleus, obviously a serious burden for the determinant hypothesis to bear. Further, among these phenomena of development which are conveniently investigated under the head of regeneration, similar difficulties have so constantly recurred, requiring similar assumptions of reserve determinants, that the theory has long since ceased to interest investigators in this field. It follows, rather than leads, investigation. Finally, in the field of heredity, just that characteristic of Mendelian inheritance—namely, the segregation of parental characters in second generation hybrids—which at first seemed to give the strongest support to the conception of a germ plasm composed of morphological determinants, has now been resolved far more satisfactorily, because more simply and workably, in terms of chemical substances.

These cases lay emphasis upon the distinction between morphological and physiological conceptions that defines the essential difference between modern preformation and modern epigenesis. Instead of a congeries of morphological determinants, the epigenesist finds in the germ a problem in physical and chemical relations. He is interested in the dynamic aspects of development, in the energy transformations. He does not seek to construct a scheme of the ultimate organization of living substance, but he *does* seek to control its operations, to predict its behavior.

In this new form, the problem of differentiation presents many interesting aspects and is being encouragingly developed. By way of illustration, recent investigations indicate that color differentiation is based essentially on a well-known chemical process, the oxidation,

namely, of a chromogen or color base in the presence of an oxidizing enzyme or oxidase. Tyrosin, for instance, a colorless chemical compound and a product of the decomposition of tissue proteids, can be oxidized, in the presence of the enzyme tyrosinase, through a series of colors: pink, red, deep brown to black, the color depending, other things equal, on the concentration of the enzyme and the duration of its activity. Tyrosinase has been isolated from many organisms, and has been definitely connected with pigment formation in many cases. We are dealing here with known substances, not hypothetical vital units; with chemical processes that can be followed in the laboratory test tube. That an organism may develop a color characteristic of its parents, in the light of these facts which are representative of a considerable number, it is only necessary that in the course of its development tyrosinase be formed under conditions that make a reaction with the tyrosin in the tissues possible. Local production of tyrosinase would lead to local coloration, to spotting or characteristic marking. The amount of tyrosinase—that is, its concentration—in connection with local conditions that might favor or inhibit the reaction in varying degrees, would determine the characteristic shade of color.

It is impossible in the brief time at my disposal to consider the various complications of this type of problem. The difficulties are very great in the way of investigations which as yet have hardly begun. Enough may have been said, however, to indicate the direction of some of the most recent and most promising work. If color characters are dependent upon chemical reactions, other characters probably are also. In fact, recent work upon the old problem of the heritability of acquired characters has brought to light interesting chemical possibilities in inheritance, and lifted the incubus of presumption laid by Weismann upon the whole subject in the shape of the determinant hypothesis almost twenty years ago.

Modern epigenesis recognizes an organized germ, more or less differentiated, but vastly simple in comparison with the preformed germ. That color may be produced at a given stage in the development of an organism, it is not necessary that the tyrosinase, upon which the formation of the color may depend, should be present as such in the fertilized ovum. It is only necessary that the conditions for its ultimate production be present—relatively simple conditions, that bring about a series of reactions of the type known in physiological chemistry as autocatalyses, in which one phase in the reaction determines the succeeding phase. Not only is this sort of conception more simple than the determinant hypothesis, but it is stimulating. It is workable. It leads to results that are sympathetic with the most advanced scientific work of the day. It is not a final explanation. It is an implement of research.

IV

The problem of vitalism need be very briefly examined. Vitalism, if it means anything in biology, interprets life in terms of forces or agencies or processes that are not found in inorganic nature. According to this definition, Aristotle was a vitalist when he conceived the development of the germ to be guided by the entelechies that determined specific and individual form in organisms. Wolff was a vitalist when he accounted for the differentiation of a homogeneous germ by the aid of a *vis essentialis*. Vital forces have long since lost their grip. They began to weaken when Wöhler, in 1828, produced in the laboratory the compound urea, till then supposed to be formed only in the bodies of organisms. They broke into full retreat under the fire of calorimetric researches of the last century which demonstrated that oxidation was oxidation, whether it took place within or without the body, and that vital heat was as surely due to chemical reaction as the heat generated by the reaction between sulphuric acid and zinc.

So Wolff's vitalism is dead. The Aristotelian vitalism, however, has a representative at the present day in the neo-vitalism of Driesch. The Aristotelian entelechy has been revamped and applied to the unexplained residuum that has escaped Driesch's experimental analysis. It is interesting that Driesch was a metaphysician first, an experimental biologist second; and that after about fifteen years of unusual activity in this second rôle, he returned to his first love. In these fifteen years he developed what he has called three proofs of vitalism. But he has not succeeded in persuading many biologists to accept his criteria of demonstration. It is difficult to take seriously his conception of entelechy, a non-substantial, non-energetic principle which yet is competent to control the developmental energies of the organism. It is but another final cause, an ultimate term in the analysis of the activities of organisms. And it has weakened Driesch's interest in biological research just as the formulation of final explanations has led to stagnation wherever we have met them along the line of biological inquiry.

In contrast with Driesch, there is a large and eager group of experimental biologists who unite in deprecating his interest in entelechies and, undaunted by its enormous complexity, in investigating the organic mechanism in the hope of reducing more of it than he was able, to terms of physics and chemistry. How far they may go is not, from the standpoint of modern biology, a pertinent question. How they may keep moving is more to the point. To this end the Drieschian entelechy offers not the slightest suggestion of encouragement.

V

Three of the four problems to which attention was invited at the beginning of this paper have now been considered. If I have succeeded

in presenting intelligibly the actual development of modern ideas, it has been shown that science has progressed, with respect to these problems, by abandoning a faith in final causes for a faith in the hypothesis that works, by draining off every stagnant suspicion of ultimateness in explanation, in the light of the conviction—the product of experience—that the ideas that serve us change with our knowledge of objective fact. I shall now attempt to show that this statement applies with equal force to the development of modern conceptions of adaptation in nature.

The problem of adaptation possesses a peculiar fascination for the imaginations of men. It inheres in every mechanism that meets a human end. Watches, beehives, steamships, reciprocating engines, footballs, blackboards, fountain pens and yellow paper—all are obviously fashioned toward ends. Why not that all-inclusive mechanism, the universe itself, and all that in it is?

When Darwin came upon the field in 1859, the widespread opposition which evolution theories had already experienced lay intrenched behind an affirmative answer to this question. These were the works, first of all, that Darwin stormed with his "Origin of Species." The struggle did not center about the problem of species, though one may well gather a contrary impression from the familiar abbreviation of the title of that epoch-making book. It is in the sub-title—"the preservation of favored races in the struggle for life"—that one discovers his real objective—a mechanical theory of adaptation in organic nature. It was just because the supporters of organic evolution had lacked such a theory that they had failed to impress, not only the thinking public, but most of their biological brethren. Darwin was not reviled as an atheist because he believed in evolution; nor for that reason did he revolutionize the whole course of modern thought. It was because his doctrine of natural selection menaced the traditional Hebraic conception of the creation that he was anathematized by the standpatters of his generation. It was because he raised such a powerful presumption against all doctrines of design in organic nature that he was able effectively to substitute for doctrines of fixity and finality the fruitful conception of change. He did destroy the doctrine of fixity of species. He did establish the doctrine of evolution in its place. But he did so by eliminating teleological theories from the list of useful hypotheses in science.

The solution of the problem of adaptation is being sought with diminishing faith in teleological formularies. These are going the way of the other final explanations that have failed to fulfill in modern science the one prime requisite—active leadership. Since Darwin's time the attention of biologists has been shifting from those secondary adaptations which provide the material for natural selection, to the direct or primary adaptive responses of the organism to given condi-

tions. The phenomena of immunity, especially to bacterial poisons that are so conspicuous in modern medicine, are adaptations of this type. It is still too early to state with any certainty the exact nature of the processes involved in such cases. That they are physico-chemical processes of great complexity seems to be clear. In this respect they ally themselves with the well-known equilibrium reactions in chemistry, and the form changes that certain crystals undergo in response to changes in temperature. Here, in the inorganic world, are relatively simple analogues, at least, of the physiological processes that are associated with adaptation in organisms. It is significant of the present attitude toward problems of adaptation, that suggestions for their solution are being thus eagerly sought among the facts of physics and chemistry.

VI

Scientific truth, then, is not concerned with final solutions. Nothing perhaps has been more conspicuously characteristic of it, in this discussion, than its incompleteness, than its plasticity, than its capacity for indefinite expansion, than its stimulating power. To my mind, this last is its crowning glory. We dwell in a world of hypotheses, and we estimate them according as they are more or less workable. To those hypotheses that approximate most closely to the demands of wide ranges of fact, we give the name of laws. It is obvious, however, that such laws have varying degrees of certainty. Scientific truth is never absolutely certain, but there are always ways of determining what it may do.

For one who seeks a basis of criticism for a contribution to science, three obvious tests may be applied. (1) It may contribute new facts; (2) it may contribute a formulation of old facts; (3) it may contribute a new idea that, in the presence of facts, may lead to a new point of departure for explorations into the unknown.

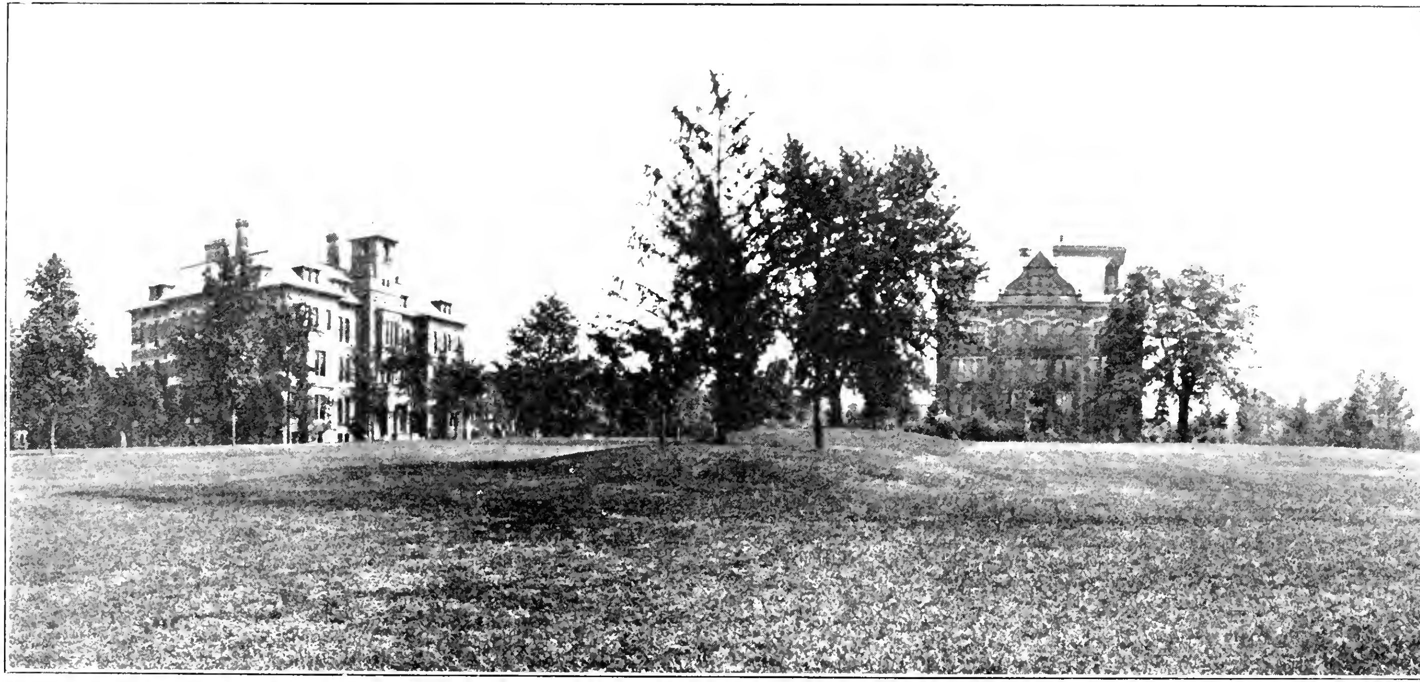
If one were to apply these tests to what seem to me to be the two most significant developments in the philosophic thought of to-day, they might be said to fall, very roughly speaking, under the second and third categories. In the former might be placed the synthetic philosophy of Spencer, an avowedly scientific philosophy, whose essential problem was to formulate the known facts of science in term of principles of evolution. This stupendous project, remarkable alike for the powers of its author and the wide range of his interests, ended in a system of philosophy, into which just enough metaphysics succeeded in creeping to justify the criticism that, in spite of all good intentions, he had not been able completely to disentangle himself from the habits of thought to which his critics were happily accustomed.

In the third category may be placed that interesting application of

the scientific method to problems of conduct which is known as pragmatism.

Pragmatism distinguishes itself at once from the synthetic philosophy in that it is non-systematic. Instead of an interest in a formulated body of knowledge it appears to possess an insatiable desire to determine practical choices. Given a problem of conduct, the solution unknown; what shall be the line of action? Here one perceives a strictly scientific situation that emphasizes the practical value of the hypothesis. The problem is to find a satisfactory path into a new region. And the answer that pragmatism gives is, trust to luck and your past experience. The truth, says James, is the hypothesis that will work. The truth, says Dewey, if I rightly apprehend him, is the hypothesis that you can work with. There is a suggestion of permanency, of stability, of future significance in the latter phrase that makes it, to my mind, more felicitous. But I do not care to dwell upon that point. What comes closer to my purpose is to point out that here is no faith in final causes, here is no suspicion even of that innocuous phantom, the unknowable. Here is no distinction between science and philosophy—if indeed pragmatists *are* philosophers, in spite of the fact that, in one form or other, they fill several of the chairs of philosophy now in our universities. Here is a faith that facts will tell their tale—will inevitably condition the movement of ideas, that one's imagination content is derivable from one's effective experience. Here is a philosophy that is working a transformation on the thought of the day. How? By abandoning the search for lofty peaks of final causation, from which to triangulate the universe according to logical necessity; by emphasizing ideas that shall not only square with the facts as we find them, but shall create others.

Such I conceive to be the most significant effects of modern scientific thought upon philosophy. They are characteristic tendencies of the present day. How one may evaluate them, however, is a problem which, for the purposes of this discussion, I have already promised to avoid.



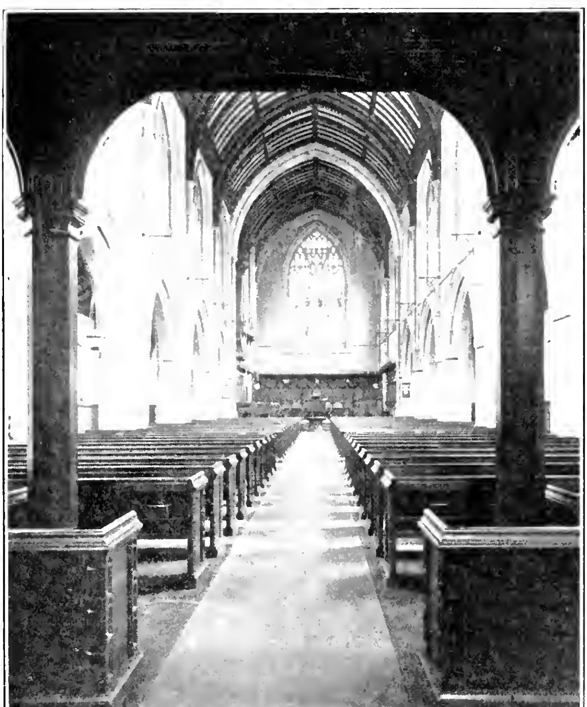
The Main Building of Adelbert College of Western Reserve University and the Main Building of Case School of Applied Science.

THE PROGRESS OF SCIENCE

THE CLEVELAND MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The sixty-fourth meeting of the American Association for the Advancement of Science, and the eleventh of the "convocation week" meetings, will be held in Cleveland from December 30 to January 4. Between twenty-five and thirty national scientific societies meet during the same week in affiliation with the association. These include the American Society of Naturalists and the societies devoted to anatomy, anthropology, astronomy, biological chemistry, botany, entomology, horticulture, mathematics, physics, physiology, psychology and zoology. There will consequently be a large gathering of scientific men at Cleveland and the tradition of convocation week will be worthily maintained.

The geologists meet at New Haven and the bacteriologists in New York, and the chemists have decided to meet hereafter in the spring and autumn instead of in the summer and winter. This change has been made by the chemists owing to the fact that those engaged in industrial work find the end of the year an inconvenient period and

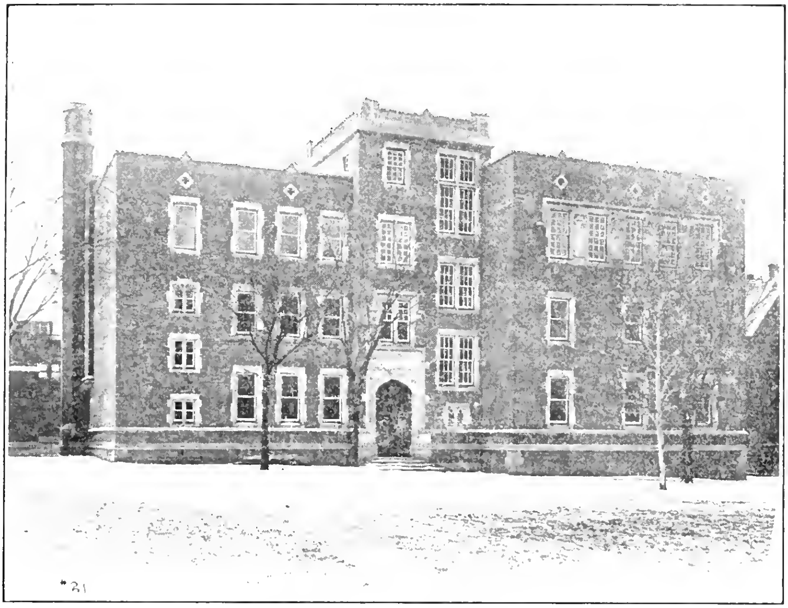


Interior of the Amasa Stone Memorial Chapel of Western Reserve University.

are besides not concerned with academic holidays. Similar conditions have led the engineers to meet apart from the American Association, and the societies devoted to economics, history, philology and other sciences which have been called ''unnatural'' and ''inexact'' meet separately. The convocation week meetings have consequently never fully represented the whole weight of science in America, and it is probably undesirable that they should attempt to do so every year. Such a gathering can only be held in one of the great cities, and there are advantages in small meetings as well as in a large congress. It would, however, be an admirable plan if once in five years all organizations concerned with research, higher education and the applications of knowledge could come together in order to demonstrate to themselves and to the world the great part that science plays in modern civilization.

Cleveland is perhaps the most central city in the United States for a scientific meeting. It is north and east of the center of population, but very close to the center of scientific population. A radius of 500 miles may include nine tenths of the scientific men of the country. The city has good hotel accommodations and, what is even more important, institutions which offer excellent places for the sessions and themselves add an attraction to the meeting. The adjacent main buildings of the Western Reserve University and the Case School of Applied Science are shown in the accompanying illustration. Western Reserve College opened in Hudson in 1827 and removed to Cleveland in 1882. As Western Reserve University since 1804, it has enjoyed a prosperous history, to the original Adelbert College there having been added a college for women and a graduate school, and in addition to professional schools of medicine and law, there are a dental school, a school of pharmacy and a library school. The medical school is one of the strongest in the country, having ten years ago adopted the requirement of three years of college work for entrance and having an endowment of one and a half million dollars, two thirds of which has been recently obtained. What is of even more consequence, it has on its faculty men of high distinction both in the scientific and clinical departments.

The Case School of Applied Science in like manner takes a leading position among our technical schools. It enjoys an educational affiliation with Western Reserve University by which students may complete their course by taking the first three years at the university and the last two years at the technical school. It will be a pleasure to physicists and chemists to meet in the laboratory named in honor of Professor Edward W. Morley, for many years professor in the university, a past president of the American Association and one of the most active of its supporters. There are other personal associations with the meeting in the fact that the vice-president of the section of mechanical science and engineering, Dr. Charles S. Howe, is president of the Case School, and Professor George T. Ladd, vice-president for the section of anthropology and psychology, is a graduate of Western Reserve University and has been a lecturer there. The other vice-presidents of the association and the presidents of the affiliated societies will give addresses of general interest, and there will be a number of discussions and general meetings that will bring together men of science working in different departments and should be attractive to those who are not professionally engaged in scientific work. The president of the association, Professor Charles E. Bessey, of the University of Nebraska, has chosen as the subject of his address ''Some of the Next Steps in Botanical Science.'' At the opening session he will introduce the president of the meeting, Dr. Edward C. Pickering, director of Harvard College Observatory.

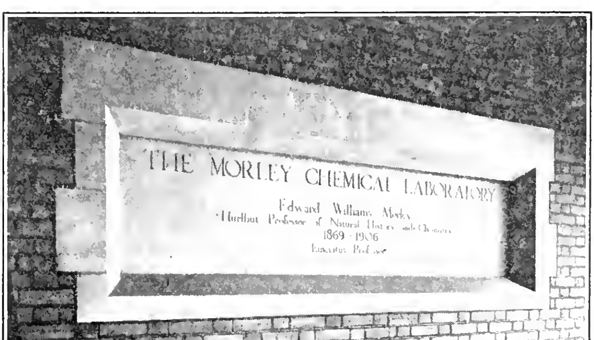


THE MORLEY LABORATORY OF WESTERN RESERVE UNIVERSITY.

THE SPREAD OF INFANTILE PARALYSIS

In an article by Mr. Charles T. Brues, of the Bussey Institution of Harvard University, on insects as agents in the spread of disease, published in the last issue of the MONTHLY, a footnote was added to the effect that since the article had been written experiments with monkeys by the author and Dr. Rosenau showed that infantile paralysis, poliomyelitis, can be transmitted from one monkey to another by the stable fly, *Stomoxys calcitrans*. A brief account of the experiments was presented before the International Congress on Hygiene and Demography in September and has been printed in the *Monthly Bulletin* of the Massachusetts State Board of Health.

Monkeys were infected by injecting virus from man into the central nervous system, and large numbers of stable flies were permitted to bite them.



TABLET IN THE MORLEY LABORATORY.

Twelve healthy monkeys were then exposed to the bites of the same flies. Six of them contracted the disease and of these three died from it. The authors state that they would like to emphasize the fact that this does not appear to be simply a mechanical transference, but rather a biological one, requiring a period of extrinsic incubation in the intermediate host. Details are, however, lacking concerning the period of incubation and the precautions used to avoid passive contamination. Dr. Flexner had in one case obtained infection by a filtrate from bedbugs which had fed on the blood of inoculated monkeys.

The preponderance of infantile paralysis in August, September and October, its prevalence in rural districts and its failure to spread in schools, asylums and the like, suggest an insect carrier, and the fact that the virus is a filterable parasite, invisible with the microscope, suggests an analogy with yellow fever and dengue known to be inoculated by mosquitoes. Dr. Flexner and his fellow workers at the Rockefeller Institute have, however, adduced strong experimental evidence that the mucous membrane of the nose is the site both of egress and ingress of the virus. While the problem in the case of infantile paralysis is not yet completely solved we may take satisfaction in the progress made by experimental methods in discovering the causes and preventing the occurrence of many of the most terrible diseases.

SCIENTIFIC ITEMS

We record with regret the death of Sir George Howard Darwin, Plumian professor of astronomy and experimental philosophy at Cambridge University; of Dr. Elie de Cyon, formerly professor at the Academy of Sciences of St. Petersburg and the author of important contributions to physiology; of Dr. Oliver Clinton Wendell, assistant professor of astronomy in Harvard University; of Eben Jenks Loomis, for a half century in the Nautical Almanac Office; and of Edwin Smith, connected with the U. S. Coast and Geodetic Survey since 1870, known especially for his work on determinations of the force of gravity.

The Royal Society has awarded its medals as follows: a Royal medal to Professor William Mitchinson Hicks, F.R.S., for his researches in mathematical physics and investigations on the theory of spectroscopy; a Royal medal to Professor Grafton Elliot Smith, F.R.S., for his researches on the comparative anatomy of the brain; the Copley medal to Professor Felix Klein, of Göttingen, For.Mem.R.S., for his researches in mathematics; the Rumford medal to Professor Heike Kamerlingh Onnes, of Leyden, for his researches at low temperatures; the Davy medal to Professor Otto Wallach, of Göttingen, for his researches on the chemistry of the essential oils and the cyclo-olefines; the Darwin medal to Dr. Francis Darwin, F.R.S., for his work in conjunction with Charles Darwin, and for his researches in vegetable physiology; the Hughes medal to Mr. William Duddell, F.R.S., for his investigations in technical electricity; the Buchanan medal to Colonel William C. Gorgas, of the United States Army, for his sanitary administration of the works of the Panama Canal.

By the will of the late Morris Loeb, formerly professor of chemistry in New York University, large sums are left to scientific, educational and charitable institutions, mainly subject to the life interest of Mrs. Loeb. Harvard University will receive $500,000 for the advancement of physics and chemistry; $25,000 is given to the American Chemical Society for a museum and $2,500 to the National Academy of Sciences. Part of the residuary estate goes to the Smithsonian Institution and to the American Museum of Natural History.

THE
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FEBRUARY, 1913

THE GEOLOGIC HISTORY OF CHINA AND ITS INFLUENCE UPON THE CHINESE PEOPLE

BY PROFESSOR ELIOT BLACKWELDER
UNIVERSITY OF WISCONSIN

THE Chinese empire includes an area larger than the United States with the addition of Alaska and our insular possessions. A large part of this vast area, however, is made up of dependencies which are but loosely joined to China proper, and are not essential to its integrity. She has lost and regained these dependencies from time to time in the past, and the same process may continue. The accompanying map will serve to show the relation of these component parts of the empire to each other and to surrounding countries.

Divested of its outlying possessions, China consists of eighteen

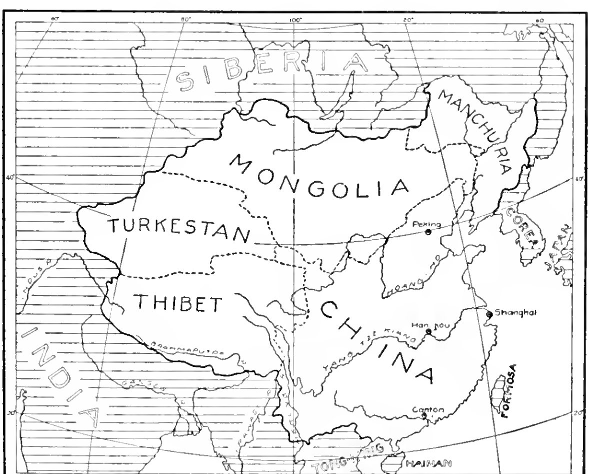

FIG. 1. SKETCH MAP OF CHINA, showing its outlying dependencies and its relations to other countries.

provinces, which may be compared in a general way to our states. The provinces are, however, generally larger than the states and on the whole much more populous. There is still greater dissimilarity in government because, whereas our states are representative democracies, the Chinese provinces were, at least until within a year or two, satrapies ruled absolutely by imperial governors or viceroys.

Not a few people in America picture China as a vast fertile plain, perhaps like the upper Mississippi valley, densely populated and intensively cultivated. In fact, however, it is so generally mountainous, that less than one tenth of its surface is even moderately flat. On the west, especially, it is ribbed with cordilleras from which its two great rivers, the Yang-tze-Kiang and the Huang-ho flow eastward to the Pacific.

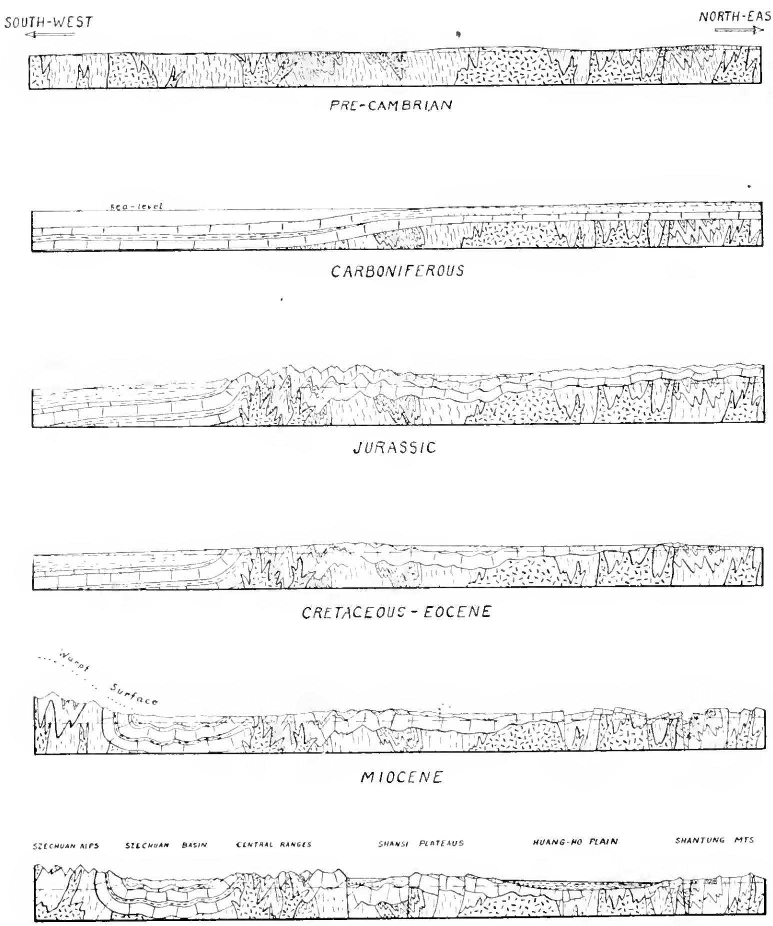

FIG. 2. DIAGRAMS TO ILLUSTRATE GEOLOGICAL CONDITIONS IN CHINA AT DIFFERENT PERIODS IN ITS HISTORY. The features are necessarily much generalized and in part hypothetical.

FIG. 3. RELIEF MAP, showing in the enclosed part how the Yellow River, by its frequent changes of course, has spread over all parts of its vast alluvial fan.

In addition to this diversity of surface there is also much variety of climate. In the northwest the conditions are dry and severe like those of Montana and central Wyoming; while in the southeast they are humid and sub-tropical, approaching those of the Philippine Islands. Such are the extremes.

It is a fact well known to geologists that continents, and therefore countries, have not always existed in their present state, but that they have been built as a result of successive events and changes of conditions. If we were to dig beneath the surface in any part of China, we should find first one stratum and then another, and we should see also that these strata have been bent, cracked and otherwise disturbed. Some of these structures are old and some young. It would be somewhat like excavating in an ancient city, where one house or temple has been built upon the ruins of its predecessor, and each affords a crude record of its time. The geologic structure of such a country as China has been de-

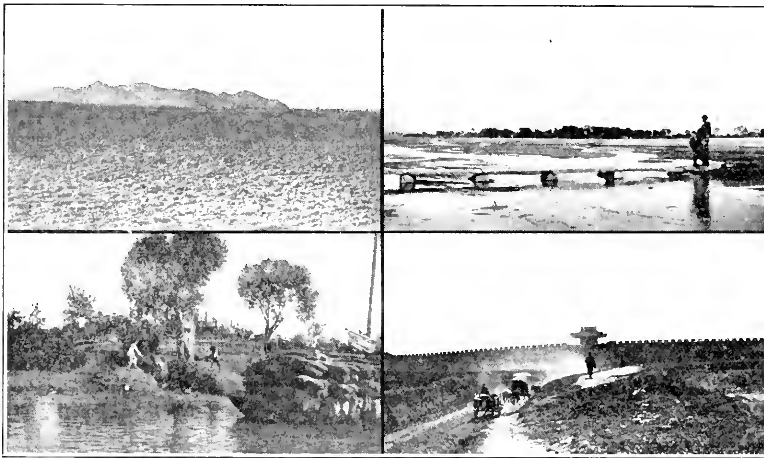

Fig. 4. Low Isolated Mountain Group in Northeastern China.

Fig. 5. Two Farmers Raising Water from the Grand Canal into the Head of an Irrigating Ditch by means of a Wicker Basket slung between them.

Fig. 6. A wide River Plain among the Mountains of Shan-tung. The bridge of stone slabs across the sand-laden river is part of the principal wheel-barrow road of the valley.

Fig. 7. A Typical City Wall, with Gate Tower.

termined largely by the rocks of which it consists, partly by the climate to which it has been subject, but chiefly by the geologic events which have occurred during its history. Of course the beginnings of that history are unknown, just as the human history of China shades into darkness when we attempt to trace it back into the remote ages. But the present features of the land are chiefly due to the later events in its life, and these have been partly worked out by the geologists who have explored its surface.

We may take as a convenient starting point for our interpretation a time far back in geologic chronology[1] when China was a land surface which had been exposed to erosion so long that nearly all the hills and mountains that may have existed there before had been worn away, leaving a relatively flat plain with groups of low hills here and there. The rocks beneath this plain were of various kinds, most of them highly folded. Eventually this surface was submerged beneath a comparatively shallow inland sea, and although the uneasy movements of the earth's body caused the sea bottom to emerge occasionally, it remained below the water nearly all through the geologic periods which constitute the Paleozoic era. By the end of that time we may picture China as a shallow sea bottom rising very gradually to a marshy coastal plain on the east. During the long intervening ages the accumulation of sediments upon the sea bottom had formed successive layers of limestone,

[1] Just before the Cambrian period.

[2] Jurassic period.

shale, and sandstone, which eventually reached a thickness of 5,000–10,000 feet.

This condition did not hold without end, for eventually[2] strong compressive forces, engendered in the underlying body of the earth, squeezed the superficial rocks into folds, and thus bulged the surface high above sea level in the region so affected. By the prompt attack of streams, winds, glaciers, and the other agencies which are incessantly sculpturing the surface of the earth, these elevated districts were, even while rising, carved into rugged mountains and deep valleys, so that the original folds were greatly disfigured even before the compressive forces ceased to operate.

It is a fact generally recognized among geologists, that in terms of geologic time such episodes of compression and folding are short-lived. They are soon followed by much longer periods during which the internal forces of the earth are quiescent, but in which the erosive agencies have free play. If any land remains indefinitely above sea level, and is not disturbed by movements from below, the mountains and hills will eventually be worn away and there will be left only a broad almost featureless plain. It is believed that China, in consequence of such a period of quiescence,[3] was reduced to a lowland from which almost all of the preexisting mountains had been removed. In this condition it probably remained for more than one geologic period, and the western part may even have been submerged beneath the sea which at that time

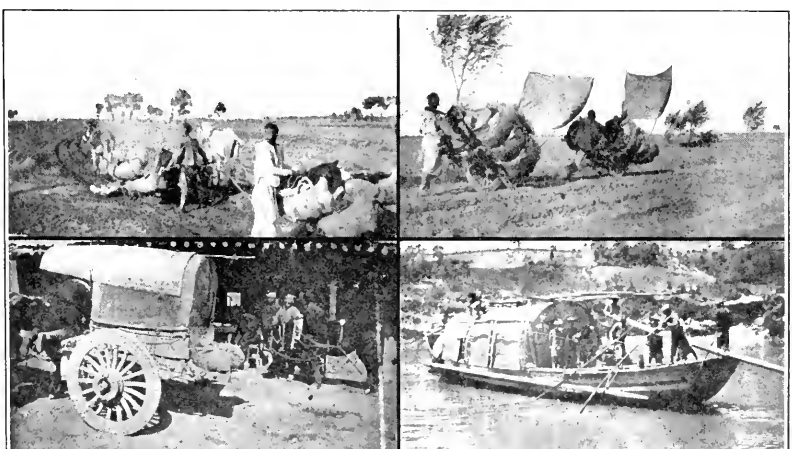

FIG. 8. HEAVILY LOADED FREIGHT WHEEL-BARROWS WITH MULES FOR MOTIVE POWER.

FIG. 9. A TYPICAL PASSENGER CART.

FIG. 10. FREIGHT WHEEL-BARROWS RIGGED TO TAKE ADVANTAGE OF A FAVORABLE WIND.

FIG. 11. A MEDIUM-SIZED HOUSE-BOAT USED ON THE YANG-TZE-KIANG AND ITS TRIBUTARIES.

[3] Cretaceous and Eocene periods.

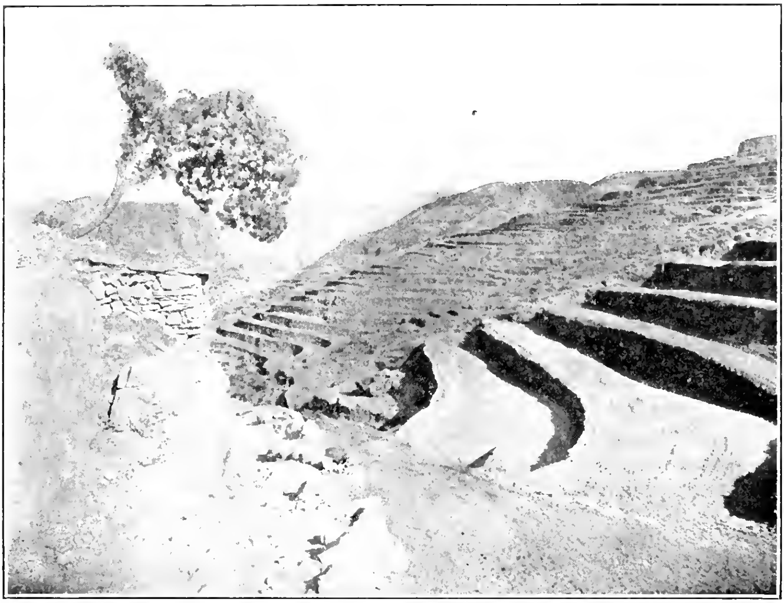

FIG. 12. SOIL RESERVOIRS ON A HILLSIDE IN THE LOESS COUNTRY.

covered northern India and part of Thibet. In that sea were deposited the thick beds of limestone which are now found in some of the western mountain ridges.

Again in the Miocene period, the forces of distortion within the earth accumulated to such strength that they were able to repeat the mashing and folding, but this time the area affected lay farther to the west and south. At the same time, or perhaps earlier, the eastern part of China was cracked in various directions; and the intervening blocks, settling somewhat unevenly upon their bases, left a group of escarpments and depressions comparable to those now to be found in western Nevada and southern Oregon. As before, the work of erosion and the leveling of the surface was at once accelerated, so that even before the deformation had spent itself the blocks were deeply scarred. It is uncertain how far this period of erosion succeeded in reducing China to base-level. The consummation may have been prevented by gentle warpings of the surface, rising very slowly here and sinking there. When compared with the great breadth of the areas affected, these changes of level seem very slight, but they are nevertheless sufficient to cause great changes in the aspect of the country.

It is one of the basal principles of physiography that streams tend to produce in their channels an almost uniform slope from their headwaters to the sea. If any part of the channel is so flat that the stream is too sluggish to carry sediment, it is built up until it reaches the re-

quired gradient; and on the other hand, if any part has too steep a declivity, it is gradually worn down to the proper slope. In consequence of this law, the parts of China which were slightly bulged above their original level were re-attacked by the branching systems of rivers with renewed vigor. By carving out the softer rocks, these have made deep valleys with intervening mountain ranges. Some of the larger rivers, such as the Yang-tze-kiang, maintained their courses in spite of the slow uplifts directly athwart their courses. A result is the magnificent series of gorges along the central Yang-tze where the great river has sawed its way through a slowly rising mass of hard complexly folded rocks.

On the other hand, the broad areas which were depressed not only below the general level of stream action, but below sea-level, were rapidly filled with sand, loam and clay washed down out of the adjacent mountains by the streams. The process of filling the depressions is the exact complement of the process of etching out the highlands. No doubt the rivers have been able in large measure to keep pace with the sinking movement of the ground, so that great rivers like the Huang-ho may have maintained perfectly graded courses across the region of depression from the mountains to the sea. While thus engaged in building up its channel, the river in time of flood frequently breaks through its low banks, shifts its channel, and then begins to fill up a

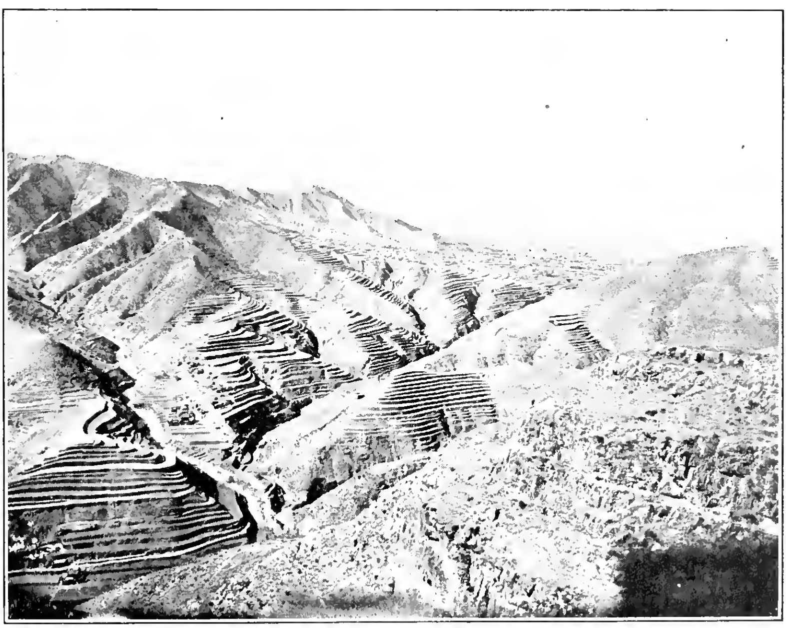

Fig. 13. Mountain Slopes in Northwestern China, terraced to prevent the erosion of the loess.

new and hitherto lower part of its surroundings. By the long continuance of this process of repeated shiftings and fillings, the great eastern plain of China and many smaller plains have been produced. It is here, where the population is densest and the rivers least confined, that the devastation by floods and their attendant famines is greatest.

By this succession of events the surface of China is believed to have reached its modern condition. We may now consider it piecemeal and see how the existing geologic conditions, which are the result of this long series of past changes, influence the habits, occupations and even mental traits of the people. Because space is limited and also because I have not seen all the physiographic divisions of China, it will not be possible for me, even briefly, to describe each of them. A few are therefore selected to show the range of variety of the whole.

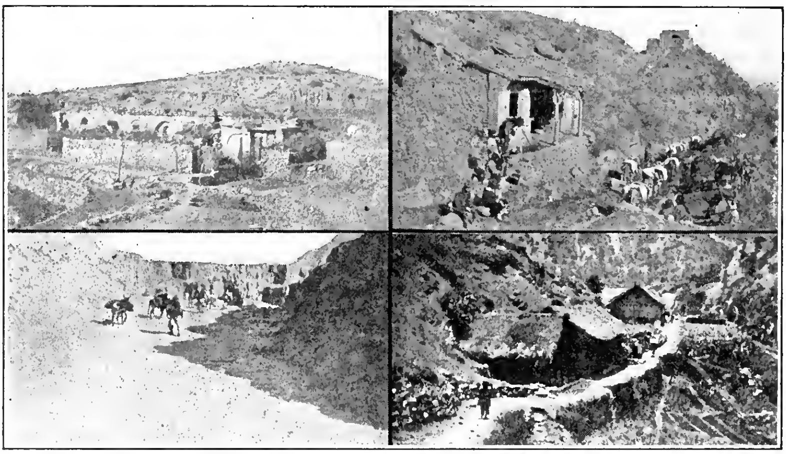

Fig. 14. Cave Houses in the Loess, faced with Stone.
Fig. 15. Men and Donkeys carrying Coal from the Mines in Shansi.
Fig. 16. A Pack Train of Donkeys, on the Imperial Highway over the Loess Plateau.
Fig. 17. A Roadside Village and small Fields at the Bottom of the Mountain Valley.

The mountains of northeastern China, typified by the province of Shantung, are unlike those of the rest of the country in several respects. Although the individual peaks are often sharp and rocky, they are generally separated by wide, flat-bottomed valleys. The process of erosion has here gone so far that the rivers have already carried away most of the land, leaving only isolated groups of low mountains. The broad valleys accommodate a relatively large number of people, who congregate in the villages dotting the intermontane plains. In contrast with most mountainous regions, travel between the different valleys is comparatively easy here, because many of the passes are but little higher than the plains themselves and constitute scarcely any obstacle to prog-

ress. Roads are plentiful, and so the cart and the wheel-barrow are the principal vehicles for through traffic.

This is one of the few parts of China where boats can be but little used. The streams are shallow and full of sand bars, and on account of the pronounced wet and dry seasons many of them are intermittent. For these reasons the majority of them are not navigable. The deeply eroded land of Shan-tung has, however, suffered a relatively recent

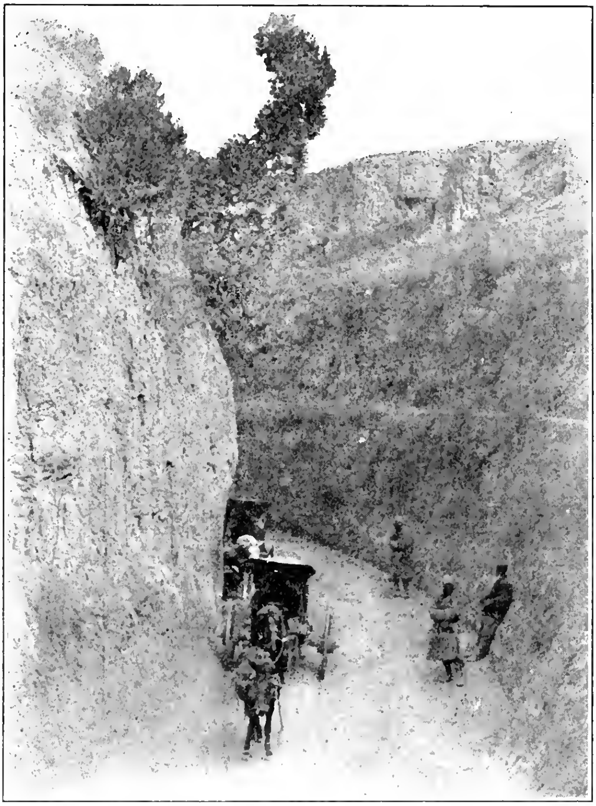

Fig. 18. A Roadway sunk deep into the Loess by Centuries of Travel.

movement—apparently a sinking of the land—which has allowed the ocean to penetrate the mouths of many of the coastal valleys. This marginal drowning has produced some excellent harbors—such as that of Chee-fu, the great silk port, and Tsing-tau, the German stronghold.

On the west, and encircling the Shantung hills, lies the great plain of the Huang-ho or Yellow River, which will serve as the type of many much smaller plains in various parts of China. As explained before, this vast gently sloping plain has been built by the Yellow River and some of its tributaries in an effort to preserve a uniform gradient across








Fig. 19. A two-man Wheel-barrow carrying a Merchant and his Stock of Goods.

Fig. 20. A River Junk.

Fig. 21. A Friendly Crowd in an Inland Town.

Fig. 22. Mongolian Camels in Northwestern China.

Fig. 23. Irrigating with Water pumped from a Well.

Fig. 24. A Sedan Chair swung between two Mules.

Fig. 25. Getting his Initiation into Farming, with Grub-hook and Basket.

Fig. 26. Coolies Fording a Mountain River.

the sunken portion of eastern China. Like the lower Mississippi and all other rivers which are building up rather than cutting down their beds, the Huang-ho is subject to frequent floods and occasional shiftings of its channel. Its course between the mountains and the sea has thus been changed more than fifteen times in the last 3,000 years.

In these incessant shiftings, the river has strewn all over an enormous area, 500 miles from north to south by 300 miles from east to west, layer after layer of fine yellow loam or silt; the very name "Yellow River," which is a translation of the Chinese "Hwang-ho," suggests the close resemblance to our own mud-laden Missouri. Almost every square foot of this vast alluvial fan is of course underlain by a deep and fertile soil and is intensively cultivated by the industrious Chinese inhabitants. One sees no large fields of grain, such as those on our Dakota prairies, but instead, thousands of small truck gardens belonging to the inhabitants of the hundreds of little mud-walled villages with which the plain is dotted. The ever-present town walls have doubtless been built because the inhabitants have no natural refuges, as their mountain cousins have, and their very accessibility has made them in the past the frequent prey of Mongol and Tartar invaders, or of rebels and rioters from within their own country.

Since the water supply of the plain is not lavish, but little rice is grown there. The dry-land grains, and such vegetables as cabbages and potatoes, are the staple crops. The small gardens are sparingly irrigated, however, in times of drought, by water taken from the canals or wells with the help of various types of crude pumps, operated by men or by donkeys.

In this densely populated alluvial plain there is practically no pasturage and no woodland. From the very natuıe of the plain it could not yield coal, which is always associated with the solid rocks. To bring fuel, as we do, from distant parts of the country is impossibly expensive for the Chinese, without an adequate railroad system, and that is still a thing of the future. When the harvest has been gathered in the autumn, the village children are therefore sent out to gather up every scrap of straw or stubble that can be used either for fodder or for fuel. The fields thus left perfectly bare in the dry winter season afford an unlimited supply of fine dust to every wind that blows. This is doubtless the explanation of the disagreeable winter dust-storms with which every foreigner who has lived in northern China is only too familiar.

Although carts and wheel-barrows are much used on the Huang-ho plain, their traffic is chiefly local. That may be due in part to the fact that the numerous wide and shifty rivers are difficult to bridge, while ferrying is relatively expensive. Another, and perhaps more important, reason is that the rivers, and particularly their old abandoned courses, afford natural waterways which are available nearly everywhere. By taking advantage of these, or by deepening them, and in some places by actually digging canals through the soft material of the plain, the Chinese have put together the wonderful system of interlaced canals for which they have been renowned since Europeans first visited them.

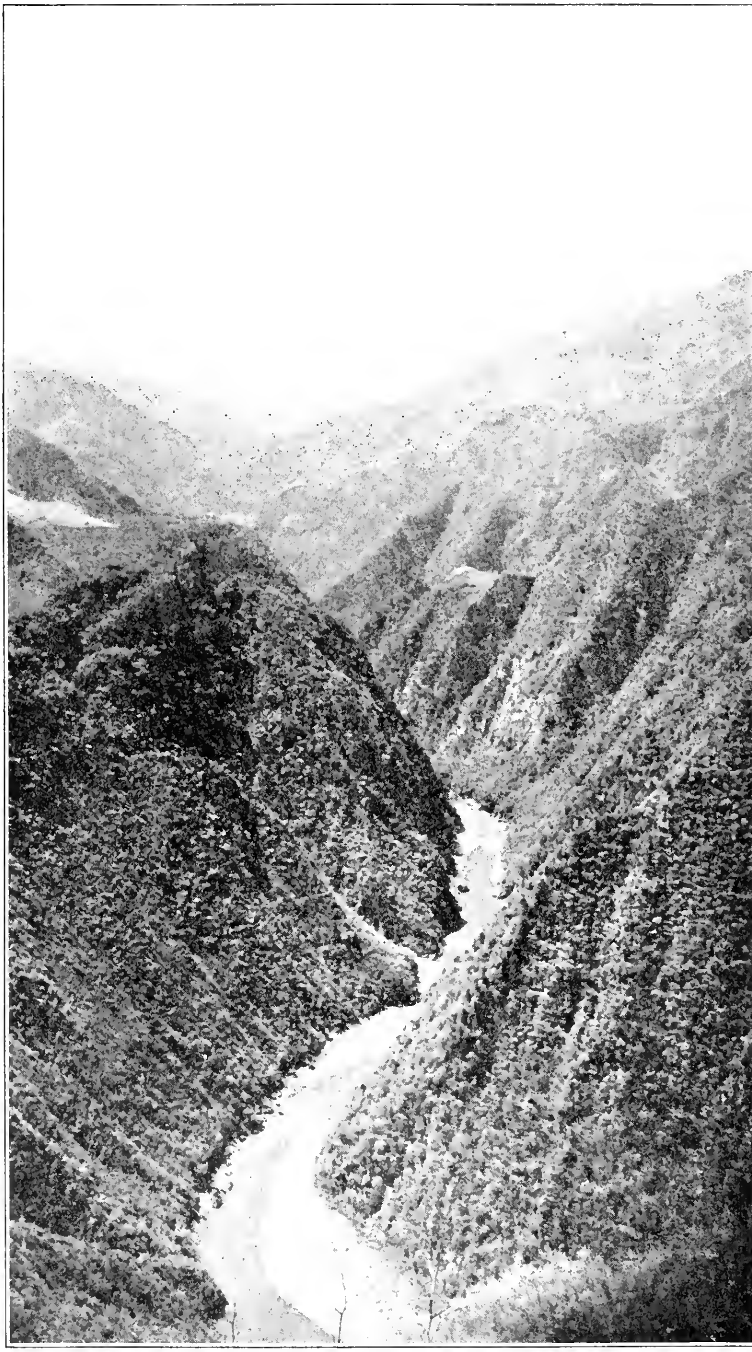

Fig. 27. A Valley in the Tsin-ling Mountains of Central China. Small cultivated fields may be seen on benches high above the river.

The thousands of junks which ply these waterways maintain a volume of inland commerce, which is inferior only to that of the great railroad countries, such as the United States. The relative freedom of communication in this great plain of the Yellow River has helped to bring about a greater homogeneity in the people than in any other equally large part of China. Here we find a single dialect in use over the entire region, whereas in some parts of southern China the natives of even adjacent valleys speak languages almost unintelligible to each other. The other common effects of isolation, such as the lack of acquaintance with the customs of outside peoples, the hatred of foreigners, the peculiar local usages, and many other things, are less prominent here than in other parts of the empire. Excepting the coastal cities, there is no safer part of China for foreigners to travel through.

West and northwest of the Yellow River plain lie the more rugged plateaus and mountains of northwest China, with their sub-arid climate presaging the approach to the deserts of Mongolia. Over much of this region the ancient limestones and sandstones are still horizontal or are gently folded, with occasional dislocations along faults. On account of the comparatively recent uplift and differential warping which this part of China has suffered, the streams have been greatly accelerated in their work, so that they have hollowed out canyons in the raised portions and have filled in the depressed basins with sand and silt. This is the region celebrated among geologists on account of the loess, or yellow earth, which lines the basins and mantles the hillsides everywhere. It is believed that this is very largely a deposit of wind-blown dust, although it has been worked over considerably by the streams from time to time. No doubt Baron von Richthofen, the distinguished German explorer, was near the truth when he concluded more than forty years ago, that the "yellow earth" was the dust of the central Asian deserts carried into China by the northwest winds. The presence of the loess determines, in large measure, the mode of living adopted by the inhabitants. Because of its fertility and moisture-conserving properties, it is well adapted to dry farming, and there is little water for irrigation. The Chinese are not content with using the level bottom lands, but successfully cultivate the hillsides wherever a deposit of the loess remains. In order to prevent the soil from washing off from these steep slopes, they build a series of stone walls, thus forming soil reservoirs or terraces. In this way nearly all of the soil is utilized.

In such a country rivers are not numerous and those which exist have many rapids and shoals. Boats are therefore but little used in northwest China. For both passenger and freight traffic, pack animals or rude vehicles are the chief reliance. For passengers there are also the palanquin or sedan-chair and the mule-litter. Where the country is not too rough, the two-wheeled cart is the usual conveyance for mer-

FIG. 28. COOLIES CARRYING FREIGHT ALONG A MOUNTAIN TRAIL WHICH HAS BEEN PARTLY WASHED OUT BY A TURBULENT STREAM.

chandise. Over the mountain passes, however, and in many of the smaller valleys, roads are so narrow that carts can not be used, and so here pack animals, particularly horses and mules, are substituted. The traveler in this part of China is often reminded of his proximity to Mongolia by the frequent sight of camels. They are nevertheless not indigenous beasts of burden and the inhabitants themselves do not use them.

In consequence of the swampy state which prevailed in this part of China far back in the Carboniferous period, thick deposits of coal were formed. These are now exposed in the deep valley slopes between beds of limestone and sandstone, and the circumstance has made Shansi province the principal coal-producing district of China. The coal is mined by very primitive methods and as there is still no adequate system of railroads in this or any other part of the empire, the product can be transported only in carts or on pack animals. Either of these modes of carriage is so expensive that it becomes unprofitable to transport the coal more than 60 to 100 miles from the mine, and so the denizens of a great part of northern China, where fuel is scarce and the winters are severe, are no more able to obtain it than as if the United States contained the only coal fields in the world. The advantages that will accrue from the building of railroads in northern China are many, but one of the greatest will be the wide distribution of this essential fuel.

In going south by west from the plateau country, one enters a region of warmer climate and more generous rainfall, which, for want of a more distinctive name, I have called the Central Ranges. This is the part of China which was particularly affected by the rock-folding movements of the Jurassic period, and which in a much more recent time has been reelevated and therefore newly attacked by the streams and other erosive agencies. Broadly regarded, it is a complex of sharp mountain ridges and spurs with narrow intervening valleys. The ridges are not so high, however, but that they are clad with vegetation, and the scenery is therefore not alpine. The surface is nevertheless very rugged and its internal relief averages at least 3,000 feet. The roughest parts of our Carolinas resemble it in a measure. In such a region obviously, there is no room for a dense population. Wherever there is a little widening of the bottom of the valley, there is a farm or occasionally a small village; and even the scattered benches high up the mountain sides are reached by steep trails and diligently cultivated. But even when all of these are combined, the total area of land under settlement is relatively small.

In this region there are no railroads whatever, and although wagon roads could be built in some places, they would be expensive, and the Chinese have not yet attempted to make them. All travel and com-

FIG. 29. RIVER SKIFFS IN ONE OF THE LIMESTONE GORGES OF THE CENTRAL RANGES.

Fig. 30. An open view in the Mountains bordering the Basin of Sze-chwan.

merce, therefore, depend on the agency of pack animals or coolies, and the roads they follow are mere trails winding around the steep mountain sides or threading the bottoms of narrow valleys, where swift streams must be forded at frequent intervals. Under such circumstances it is evident that there can be but little effective traffic. Only comparatively light and expensive articles can be transported long distances. Around the edges of the mountain mass where the populous cities of the adjoining plains can be reached with one or two days' travel, there has been for centuries an important trade in lumber. The mountains have now been so largely deforested, however, that it is necessary to go farther and farther back into the heads of the valleys to find large trees. Hence, only the more expensive kinds of lumber such as coffin boards—which are absolutely indispensable, even to the poorer classes, —can profitably be brought out. These are often carried for 20 or 30 miles on the backs of coolies—a costly mode of transportation. The smaller trees and brush the mountaineers convert into charcoal, which they carry on their own backs down to the towns along the foothills.

Lack of transportation facilities is doubtless the chief reason why the opium poppy has in the past been widely cultivated in this part of China, although the practise has lately been prohibited by the government. The advantage in poppy culture was that it could be carried on in small scattered fields and the product was so valuable for unit of weight that it would pay for long-distance transportation across the mountains. The inhabitants of the region themselves were not, however, generally addicted to the use of the drug.

The rainfall of the central mountain region is sufficient to supply the many springs and tributary brooks of which the people have made use in irrigation. The mildness of the climate here permits the growing of rice, and by terracing the hillsides they are able to make a succession of narrow curved basins in which the aquatic crop may be grown. For the cultivation of rice it is necessary that the fields be completely submerged during part of the season, and so there must be a plentiful supply of water.

On the larger rivers such as the Han and the Yang-tze, and their chief tributaries, boats are successfully used. In fact, the Chinese river boatmen are so skilful in the handling of their high-prowed skiffs, that they navigate canyons full of rapids which most of us would consider too dangerous to attempt. The descent of one of these rivers is an easy although exciting experience. The return trip, however, is slow and laborious, for the boats must be dragged upstream by coolies harnessed to a long bamboo rope, which has the advantage of being very light as well as strong. In the many places where the river banks are so precipitous that it is impossible to walk along them, it becomes neces-

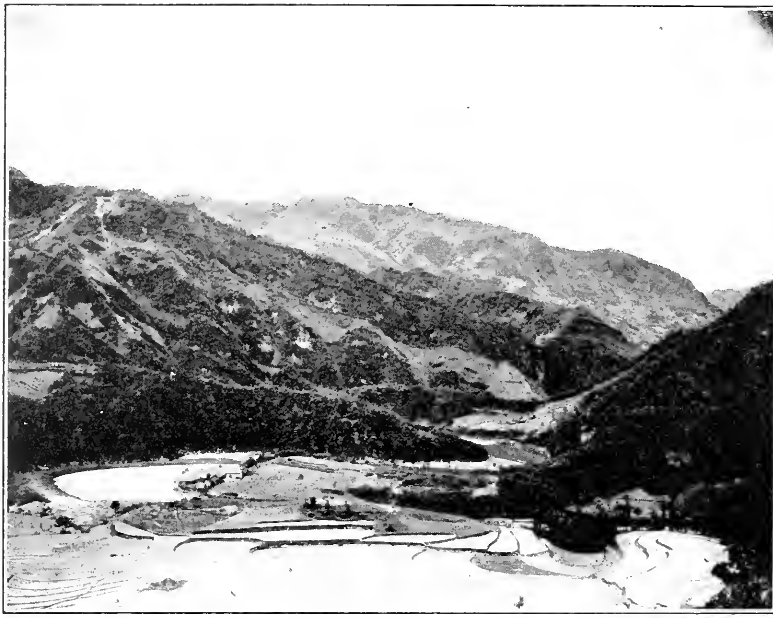

FIG. 31. A VALLEY IN THE CENTRAL RANGES. In the foreground are a series of terraced rice fields now filled with water.

sary for the boatmen to pole around the cliff or to zigzag from one side of the river to the other to take advantage of every foothold.

Through the central part of this mountain uplift, the great Yang-tze River, which in its lower course readily accommodates large ocean-going vessels, has carved a succession of superb gorges. In many places the gray limestone walls rise from 3,000 to 4,000 feet above the river, and the stream is compressed into less than a tenth of its usual width. Difficult and dangerous as are these canyons, beset with rapids and whirlpools, they afford the only ready means of communication between eastern China and the fertile basin of Sze-chuan, which lies west of the Central Ranges.

Without the highway of the Yang-tze, this great province, four times as large as Illinois and with more people than all of our states east of the Mississippi River, would be unable to export its many rich products or to enjoy the commerce of outside provinces and nations. It has been effectually barred off from India and Burma by the succession of high ranges and deep canyons which appear to be due primarily to the great epoch of folding in the Miocene period. Sze-chuan is a broad basin which has never been depressed low enough to force the streams to level its bottom with alluvial deposits, as in the Yellow River plain to the east; nor does it seem to have been elevated into a high plateau which would have been carved by many streams into a

rugged mountain country. The soft red sandstone beds which underlie it have therefore been sculptured into a network of valleys with intervening red hills or buttes. With a climate as mild and moist as that of Alabama, and a diversified topography, there is opportunity for many industries, and for the cultivation of a great variety of crops. Sze-chuan leads all the provinces in the exportation of silk. Here grow the lacquer and oil nut trees and a wide range of field and garden fruits, grains and vegetables. Ample water for irrigation and especially for rice-culture is supplied by the many perennial streams which descend from the encircling mountains. These uplifted and now mountainous tracts have also served as a barrier to invaders from all directions, so that this has been less subject to wars than almost any other part of China, and hence has been more stable in development. Its inhabitants are among the most substantial and progressive components of the Chinese nation.

We now come to the last of the geologic divisions which were laid out for consideration. From the Sze-chuan basin southwest to the

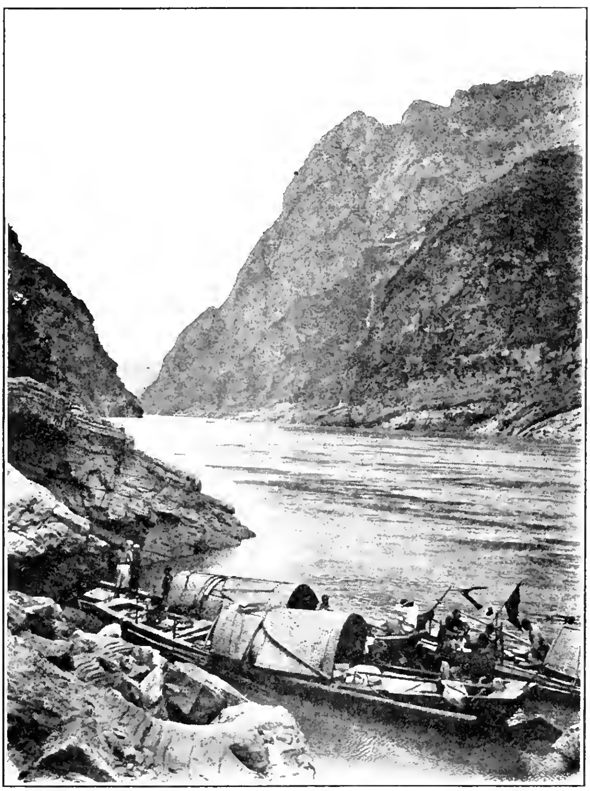

Fig. 32. One of the great Limestone Gorges through which the Yang-tze-kiang pierces the Central Ranges.

confines of India there extends a series of high mountain ranges separated by deep and narrow valleys, all trending in a south or southeasterly direction. Although not so high above sea-level as the mountains north and south of Thibet, these ranges are an even more effective barrier to travel because they are so continuous and the relief is so great. Not only is there no waterway, but there are no wagon roads, and the building of a railroad would be a stupendous and expensive engineering task. Such a road would necessarily involve the making of a succession of long bridges and tunnels. Here, as in the Central Ranges, settlements are limited to the rare open spots in the bottoms of valleys, and so the population is sparse indeed. The total commerce is very small in volume, because goods must be carried almost entirely on the backs of coolies. The rugged characteristics of the region are evidently the direct result of the recency of the compressive movement which produced the tremendous mountain folds, and perhaps are still more due to the renewed uplifts which have permitted the streams to continue the carving of their deep gorges. This part of China is geologically very young, and to quote the words of the distinguished old geologist of California, Joseph LeConte, "the wildness of youth (here) has not yet been tempered by the mellowness of age."

FRENCH GEODESY

BY THE LATE HENRI POINCARÉ
TRANSLATED BY GEORGE BRUCE HALSTED

EVERY one understands our interest in knowing the form and dimensions of our earth; but some persons will perhaps be surprised at the exactitude sought after. Is this a useless luxury? What good are the efforts so expended by the geodesist?

Should this question be put to a congressman, I suppose he would say: "I am led to believe that geodesy is one of the most useful of the sciences; because it is one of those costing us most dear." I shall try to give you an answer a little more precise.

The great works of art, those of peace as well as those of war, are not to be undertaken without long studies which save much groping, miscalculation and useless expense. These studies can only be based upon a good map. But a map will be only a valueless phantasy if constructed without basing it upon a solid framework. As well make stand a human body minus the skeleton.

Now, this framework is given us by geodesic measurements; so, without geodesy, no good map; without a good map, no great public works.

These reasons will doubtless suffice to justify much expense; but these are arguments for practical men. It is not upon these that it is proper to insist here; there are others higher and, everything considered, more important.

So we shall put the question otherwise: can geodesy aid us the better to know nature? Does it make us understand its unity and harmony? In reality an isolated fact is of slight value, and the conquests of science are precious only if they prepare for new conquests.

If therefore a little hump were discovered on the terrestrial ellipsoid, this discovery would be by itself of no great interest. On the other hand, it would become precious if, in seeking the cause of this hump, we hoped to penetrate new secrets.

Well, when, in the eighteenth century, Maupertuis and La Condamine braved such opposite climates, it was not solely to learn the shape of our planet, it was a question of the whole world-system.

If the earth was flattened, Newton triumphed and with him the doctrine of gravitation and the whole modern celestial mechanics.

And to-day, a century and a half after the victory of the Newtonians, think you geodesy has nothing more to teach us?

We know not what is within our globe. The shafts of mines and borings have let us know a layer of 1 or 2 kilometers thickness, that is to say, the millionth part of the total mass; but what is beneath?

Of all the extraordinary journeys dreamed by Jules Verne, perhaps that to the center of the earth took us to regions least explored.

But these deep-lying rocks we can not reach exercise from afar their attraction which operates upon the pendulum and deforms the terrestrial spheroid. Geodesy can therefore weigh them from afar, so to speak, and tell us of their distribution. Thus will it make us really see those mysterious regions which Jules Verne only showed us in imagination.

This is not an empty illusion. M. Faye, comparing all the measurements, has reached a result well calculated to surprise us. Under the oceans, in the depths, are rocks of very great density; under the continents, on the contrary, are empty spaces.

New observations will modify perhaps the details of these conclusions.

In any case, our venerated dean has shown us where to search and what the geodesist may teach the geologist, desirous of knowing the interior constitution of the earth, and even the thinker wishing to speculate upon the past and the origin of this planet.

And now, why have I entitled this chapter *French Geodesy?* It is because, in each country, this science has taken, more than all others perhaps, a national character. It is easy to see why.

There must be rivalry. The scientific rivalries are always courteous, or at least almost always: in any case, they are necessary, because they are always fruitful.

Well, in those enterprises which require such long efforts and so many collaborators the individual is effaced, in spite of himself, of course; no one has the right to say: this is my work. Therefore it is not between men, but between nations, that rivalries go on.

So we are led to seek what has been the part of France. Her part I believe we are right to be proud of.

At the beginning of the eighteenth century long discussions arose between the Newtonians who believed the earth flattened, as the theory of gravitation requires, and Cassini, who, deceived by inexact measurements, believed our globe elongated. Only direct observation could settle the question. It was our Academy of Sciences that undertook this task, gigantic for the epoch.

While Maupertuis and Clairaut measured a degree of meridian under the polar circle, Bouguer and La Condamine went toward the Andes Mountains, in regions then under Spain which to-day are the Republic of Ecuador.

Our envoys were exposed to great hardships. Traveling was not as easy as at present.

Truly, the country where Maupertuis operated was not a desert, and he even enjoyed, it is said, among the Laplanders those sweet satisfac-

tions of the heart that real arctic voyagers never know. It was almost the region where, in our days, comfortable steamers carry, each summer, hosts of tourists and young English people. But in those days Cook's agency did not exist and Maupertuis really believed he had made a polar expedition.

Perhaps he was not altogether wrong. The Russians and the Swedes carry out to-day analogous measurements at Spitzbergen, in a country where there is real ice-cap. But they have quite other resources, and the difference of time makes up for that of latitude.

The name of Maupertuis has reached us much scratched by the claws of Doctor Akakia; the scientist had the misfortune to displease Voltaire, who was then the king of mind. He was first praised beyond measure; but the flatteries of kings are as much to be dreaded as their displeasure, because the days after are terrible. Voltaire himself knew something of this.

Voltaire called Maupertuis, my amiable master in thinking, marquis of the polar circle, dear flattener out of the world and Cassini, and even, flattery supreme, Sir Isaac Maupertuis; he wrote him: "Only the king of Prussia do I put on a level with you; he only lacks being a geometer." But soon the scene changes, he no longer speaks of deifying him, as in days of yore the Argonauts, or of calling down from Olympus the council of the gods to contemplate his works, but of chaining him up in a madhouse. He speaks no longer of his sublime mind, but of his despotic pride, plated with very little science and much absurdity.

I care not to relate these comico-heroic combats; but permit me some reflections on two of Voltaire's verses. In his "Discourse on Moderation" (no question of moderation in praise and criticism), the poet has written:

> You have confirmed in regions drear
> What Newton discerned without going abroad.

These two verses (which replace the hyperbolic praises of the first period) are very unjust, and doubtless Voltaire was too enlightened not to know it.

Then, only those discoveries were esteemed which could be made without leaving one's house.

To-day, it would rather be theory that one would make light of.

This is to misunderstand the aim of science.

Is nature governed by caprice, or does harmony rule there? That is the question. It is when it discloses to us this harmony that science is beautiful and so worthy to be cultivated. But whence can come to us this revelation, if not from the accord of a theory with experiment? To seek whether this accord exists or if it fails, this therefore is our aim. Consequently these two terms, which we must compare, are as indispensable the one as the other. To neglect one for the other would be non-

sense. Isolated, theory would be empty, experiment would be blind; each would be useless and without interest.

Maupertuis therefore deserves his share of glory. Truly, it will not equal that of Newton, who had received the spark divine; nor even that of his collaborator Clairaut. Yet it is not to be despised, because his work was necessary, and if France, outstripped by England in the seventeenth century, has so well taken her revenge in the century following, it is not alone to the genius of Clairauts, d'Alemberts, Laplaces that she owes it; it is also to the long patience of the Maupertuis and the La Condamines.

We reach what may be called the second heroic period of geodesy. France is torn within. All Europe is armed against her; it would seem that these gigantic combats might absorb all her forces. Far from it; she still has them for the service of science. The men of that time recoiled before no enterprise, they were men of faith.

Delambre and Méchain were commissioned to measure an arc going from Dunkirk to Barcelona. This time there was no going to Lapland or to Peru; the hostile squadrons had closed to us the ways thither. But, though the expeditions are less distant, the epoch is so troubled that the obstacles, the perils even, are just as great.

In France, Delambre had to fight against the ill will of suspicious municipalities. One knows that the steeples, which are visible from so far, and can be aimed at with precision, often serve as signal points to geodesists. But in the region Delambre traversed there were no longer any steeples. A certain proconsul had passed there, and boasted of knocking down all the steeples rising proudly above the humble abode of the sans-culottes. Pyramids then were built of planks and covered with white cloth to make them more visible. That was quite another thing: with white cloth! What was this rash person who, upon our heights so recently set free, dared to raise the hateful standard of the counter-revolution? It was necessary to border the white cloth with blue and red bands.

Méchain operated in Spain; the difficulties were other; but they were not less. The Spanish peasants were hostile. There steeples were not lacking: but to install oneself in them with mysterious and perhaps diabolic instruments, was it not sacrilege? The revolutionists were allies of Spain, but allies smelling a little of the stake.

"Without cease," writes Méchain, "they threaten to butcher us." Fortunately, thanks to the exhortations of the priests, to the pastoral letters of the bishops, these ferocious Spaniards contented themselves with threatening.

Some years after, Méchain made a second expedition into Spain: he proposed to prolong the meridian from Barcelona to the Balearics. This was the first time it had been attempted to make the triangulations

overpass a large arm of the sea by observing signals installed upon some high mountain of a far-away isle. The enterprise was well conceived and well prepared; it failed however.

The French scientist encountered all sorts of difficulties of which he complains bitterly in his correspondence. "Hell," he writes, perhaps with some exaggeration, "hell and all the scourges it vomits upon the earth, tempests, war, the plague and black intrigues, are therefore unchained against me!"

The fact is that he encountered among his collaborators more of proud obstinacy than of good will and that a thousand accidents retarded his work. The plague was nothing, the fear of the plague was much more redoubtable; all these isles were on their guard against the neighboring isles and feared lest they should receive the scourge from them. Méchain obtained permission to disembark only after long weeks upon the condition of covering all his papers with vinegar; this was the antisepsis of that time.

Disgusted and sick, he had just asked to be recalled, when he died.

Arago and Biot it was who had the honor of taking up the unfinished work and carrying it on to completion.

Thanks to the support of the Spanish government, to the protection of several bishops and, above all, to that of a famous brigand chief, the operations went rapidly forward. They were successfully completed, and Biot had returned to France when the storm burst.

It was the moment when all Spain took up arms to defend her independence against France. Why did this stranger climb the mountains to make signals? It was evidently to call the French army. Arago was able to escape the populace only by becoming a prisoner. In his prison his only distraction was reading in the Spanish papers the account of his own execution. The papers of that time sometimes gave out news prematurely. He had at least the consolation of learning that he died with courage and like a Christian.

Even the prison was no longer safe; he had to escape and reach Algiers. There, he embarked for Marseilles on an Algerian vessel. This ship was captured by a Spanish corsair, and behold Arago carried back to Spain and dragged from dungeon to dungeon, in the midst of vermin and in the most shocking wretchedness.

If it had only been a question of his subjects and his guests, the dey would have said nothing. But there were on board two lions, a present from the African sovereign to Napoleon. The dey threatened war.

The vessel and the prisoners were released. The port should have been properly reached, since they had on board an astronomer; but the astronomer was seasick, and the Algerian seamen, who wished to make Marseilles, came out at Bougie. Thence Arago went to Algiers, traversing Kabylia on foot in the midst of a thousand perils. He was long

detained in Africa and threatened with the convict prison. Finally he was able to get back to France; his observations, which he had preserved and safe-guarded under his shirt, and, what is still more remarkable, his instruments, had traversed unhurt these terrible adventures.

Up to this point, not only did France hold the foremost place, but she occupied the stage almost alone.

In the years which follow she has not been inactive and our staff-office map is a model. However, the new methods of observation and calculation have come to us above all from Germany and England. It is only in the last forty years that France has regained her rank. She owes it to a scientific officer, General Perrier, who has successfully executed an enterprise truly audacious, the junction of Spain and Africa. Stations were installed on four peaks upon the two sides of the Mediterranean. For long months they awaited a calm and limpid atmosphere. At last was seen the little thread of light which had traversed 300 kilometers over the sea. The undertaking had succeeded.

To-day have been conceived projects still more bold. From a mountain near Nice will be sent signals to Corsica, not now for geodesic determinations, but to measure the velocity of light. The distance is only 200 kilometers; but the ray of light is to make the journey there and return, after reflection by a mirror installed in Corsica. And it should not wander on the way, for it must return exactly to the point of departure.

Ever since, the activity of French geodesy has never slackened. We have no more such astonishing adventures to tell; but the scientific work accomplished is immense. The territory of France beyond the sea, like that of the mother country, is covered by triangles measured with precision.

We have become more and more exacting and what our fathers admired does not satisfy us to-day. But in proportion as we seek more exactitude, the difficulties greatly increase; we are surrounded by snares and must be on our guard against a thousand unsuspected causes of error. It is needful, therefore, to create instruments more and more faultless.

Here again France has not let herself be distanced. Our appliances for the measurement of bases and angles leave nothing to desire, and I may also mention the pendulum of Colonel Defforges, which enables us to determine gravity with a precision hitherto unknown.

The future of French geodesy is at present in the hands of the Geographic Service of the army, successively directed by General Bassot and General Berthaut. We can not sufficiently congratulate ourselves upon it. For success in geodesy, scientific aptitudes are not enough; it is necessary to be capable of standing long fatigues in all sorts of climates; the chief must be able to win obedience from his collaborators

and to make obedient his native auxiliaries. These are military qualities. Besides, one knows that, in our army, science has always marched shoulder to shoulder with courage.

I add that a military organization assures the indispensable unity of action. It would be more difficult to reconcile the rival pretensions of scientists jealous of their independence, solicitous of what they call their fame, and who yet must work in concert, though separated by great distances. Among the geodesists of former times there were often discussions, of which some aroused long echoes. The Academy long resounded with the quarrel of Bouguer and La Condamine. I do not mean to say that soldiers are exempt from passion, but discipline imposes silence upon a too sensitive self-esteem.

Several foreign governments have called upon our officers to organize their geodesic service: this is proof that the scientific influence of France abroad has not declined.

Our hydrographic engineers contribute also to the common achievement a glorious contingent. The survey of our coasts, of our colonies, the study of the tides offer them a vast domain of research. Finally I may mention the general leveling of France which is carried out by the ingenious and precise methods of M. Lallemand.

With such men we are sure of the future. Moreover, work for them will not be lacking; our colonial empire opens for them immense expanses illy explored. That is not all: the International Geodetic Association has recognized the necessity of a new measurement of the arc of Quito, determined in days of yore by La Condamine. It is France that has been charged with this operation; she had every right to it, since our ancestors had made, so to speak, the scientific conquest of the Cordilleras. Besides, these rights have not been contested and our government has undertaken to exercise them.

Captains Maurain and Lacombe completed a first reconnaissance, and the rapidity with which they accomplished their mission, crossing the roughest regions and climbing the most precipitous summits, is worthy of all praise. It won the admiration of General Alfaro, President of the Republic of Ecuador, who called them "los hombres de hierro," the men of iron.

The final commission then set out under the command of Lieutenant-Colonel (then Major) Bourgeois. The results obtained have justified the hopes entertained. But our officers have encountered unforeseen difficulties due to the climate. More than once, one of them has been forced to remain several months at an altitude of 4,000 meters, in the clouds and the snow, without seeing anything of the signals he had to aim at and which refused to unmask themselves. But thanks to their perseverance and courage, there resulted from this only a delay and an increase of expense, without the exactitude of the measurements suffering therefrom.

THE RÔLE OF MEMBRANES IN CELL-PROCESSES

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THE importance of membranes in vital processes has long been recognized. From the earliest times anatomists have been impressed with the frequency with which thin sheets of solid material occur as elements of structure in organisms. Even elementary methods of analysis show that the materials composing the most various organs often tend to dispose themselves in thin, continuous layers. Thus the entire body is enclosed in an extremely resistant and impermeable layer, the skin. Each of the internal organs has its own characteristic enclosing membrane; the peritoneum lines the body-cavity and invests the intestine and its associated glands, the heart is enclosed in the pericardium, the lungs in the pleura, the central nervous system in the pia mater; the muscles are closely surrounded by thin connective tissue sheaths, or perimysia; the walls of the blood-vessels and of the intestine and other hollow viscera consist of several distinct concentric layers. Various products of animals, like the eggs of birds and reptiles, often show this tendency. Plants also deposit a great part of their structural materials in layers; the wood forms concentric circles; leaves and fruits have thin and often waterproof membranous coverings; the orange is partitioned by a system of membranes and each smaller portion of pulp has a membrane of its own. The instances, in fact, are innumerable. Evidently the tendency to deposit material in thin continuous sheaths is highly characteristic of organisms.

This much was clear at a time when anatomists were limited to direct and unaided vision. When the microscope came into use the existence of a similar tendency soon became evident in the minutest tissue-elements. The living substance exhibited itself everywhere as minutely subdivided by innumerable thin partitions, or membranes, giving it a characteristic honeycomb-like or cellular structure. These partitions isolate the enclosed portions of living substance and render them at least mechanically separable. Hence the conception that each of these minute membrane-enclosed masses of gelatinous or viscid "protoplasmic" material is an independently living entity, or elementary physiological unit, gained ground, and, as all know, has been universally adopted in biology. The name "cell," originally applied to the minute spaces themselves, has been transferred to the protoplasmic mass within, by whose activity the enclosing membrane is itself formed.

Thus it was early recognized that cells tend to separate materials

from their surfaces and deposit them in the form of definite coherent layers or membranes. Similar membranes may also be formed in the cell-interior. Of these, the best known is the nuclear membrane. Hence, in considering the general organization of the cell, cytoplasm and nucleus are usually described as bounded by definite structurally distinct layers, plasma-membrane and nuclear membrane. Vacuole-membranes, sphere-membranes and plastid-membranes may also exist in certain cells. To all of these structures it has been customary to ascribe a more or less mechanical or simply protective or isolating function. On the other hand, many cells show no optically distinguishable membranes, either at their surfaces or in their interior; certain ameboid cells and the blood-corpuscles of vertebrates are apparently without membranes and are often described as "naked masses of protoplasm." Yet in such cases the nakedness is only apparent, for it can readily be shown that these cells have membranes which are highly definite in character, but whose existence can be demonstrated only by certain forms of physiological experimentation.

The membranes whose physiological rôle forms the subject of this article are not to be identified with those more or less conspicuous layers separated at the surfaces of many animal and plant cells. The cellulose membranes of plant cells and the various cuticular structures of animal cells are dead structures, whose function is typically passive and mechanical. They are to be sharply distinguished from the membranes about to be considered, whose rôle is a characteristically active one, and, as I believe, fundamentally important in the life of all cells. These membranes are present in all living cells without exception, whether a visible external layer is present or not. Thus red blood corpuscles, though typically naked cells, show by their behavior in salt-solutions of varying concentration that they are bounded by a difficultly permeable surface-layer which is different in its physical properties from the internal protoplasm—having in fact the essential properties of a semi-permeable membrane. Plant cells, like those of *Spirogyra,* also behave in such solutions as if the surface-layer of the protoplasm were semi-permeable; the visible cellulose membrane plays no part whatever in the osmotic process (plasmolysis) observed under such conditions, while the invisible surface-film of the protoplasm is all-important. Hence in the case of plant cells the conceptions of cell-membrane—*i. e.,* the hardened secretion of cellulose—and of plasma-membrane—or semi-permeable surface layer of the living protoplasm—have to be kept sharply distinct. It is the plasma-membrane, the most external layer of the living protoplasm, with which I shall be chiefly concerned in the present article, and I propose to discuss briefly various questions which arise in reference to this structure: what is its physical and chemical nature? what are the conditions of its formation? and how does it influence the characteristic activities of the cell?

Before dealing with the case of the living plasma-membrane, it will be necessary briefly to describe some of the methods by which artificial membranes. similar in many of their osmotic and other physical properties to plasma-membranes, may be prepared, and to consider some of the properties of these membranes. The tendency of the living cell (or living system) to surround itself with a membrane will then be seen to be in no sense a distinctively vital peculiarity, but one which it exhibits in common with a great many non-living systems. There is little doubt that the formation of membranes at the surface of small masses of living protoplasm is a particular instance of the general class of phenomena known collectively as "surface-processes"—processes, that is, occuring as manifestations of the special form of energy, surface-energy, which resides at the surface of separation between materials which do not freely intermix. Consider any material system consisting of various kinds of matter in various states of aggregation, *i. e.*, what the physical chemists call a heterogeneous system, or a *polyphasic* system. Such a system may be analyzed into a certain number of components, each of which is physically and chemically homogeneous. Each such component is a *phase*. Oil-drops in a permanent emulsion form one phase, the water a second phase, the soap films at the surface of each droplet a third. Living protoplasm is a good instance of such a polyphasic system. It is—at least in certain forms, *e. g.*, the protoplasm of egg-cells—an emulsion-like or foam-like mixture consisting of various fluid droplets or alveoli (which are supposedly droplets of oil or other fluid containing dissolved substances), separated by another fluid which is typically an aqueous colloidal solution of proteins and lipoids with various additional substances—salts, sugars, amino-acids—in solution. Each droplet or alveolus is a phase; so also is each colloidal particle, or each surface-film, or the interstitial suspension-medium or solvent. At the surface of contact between any two phases a certain tension exists, acting tangentially to the surface; this is the "surface-tension" which (if positive in value) tends to minimize the area of the surface. Each surface, or phase-boundary, is thus the seat of a particular form of energy, surface-energy, of which the intensity-factor is the surface-tension (T), the capacity-factor the total area of the surface (A). The total surface-energy (E) resident at any surface thus equals TA. The tension varies according to the nature of both of the contiguous phases: for water in contact with air it is *ca.* 75 dynes per linear centimeter, *i. e.*, the pull of a ribbon-shaped portion of water-surface one centimeter wide is about one twelfth of a gram; for water in contact with oil it is *ca.* 23 dynes per centimeter; for oil in contact with air it is *ca.* 33 dynes. Now the distribution of the substances present in any such system is influenced in a remarkable manner by these surface-energies. Every one is familiar with the fact that oil spreads over the surface of pure water. This is a case in point: why does the oil not simply float

in droplets on the surface instead of spreading out in an extremely thin continuous layer? A consideration of the conditions of surface-tension at once explains this (Fig. 1). An oil-drop placed on the surface of water is subjected to the pull of three tensions, viz.: those at its own two surfaces (t_1 and t_2), where it touches air and water, respectively, and which tend to round it off, and that of the pure water at its margin (t_3), which tends to spread it. But the tensions t_1 and t_2 are together less than the tension t_3: the oil is thus rapidly drawn out over the surface by the superior pull of the water-air tension at its margin. Hence the water-air surface, that with high tension, disappears and is replaced by a surface with lower tension. The total surface-energy has been diminished, part having been transformed into mechanical energy and heat. If, instead of the case of a floating oil-drop, we take that of some soluble substance which is produced locally within the water near the surface—*e. g.*, a soap or a protein, a solution of which has a lower tension than pure water—we find essentially the same phenomenon; the substance is spread out over the surface, and this effect will continue so long as the addition of further quantities of the substance to the surface-layer continues to lower the surface-tension. The end-effect will be to concentrate the substance at the phase-boundary. This phenomenon is the expression of a general law, the law of Willard Gibbs and J. J. Thomson, which describes the part played by surface-energies in the distribution of soluble substances in a polyphasic system. In the present case, the process of surface-concentration will go on until some equilibrium is reached, *e. g.*, where the loss of substance from the surface by diffusion balances its collection there under the influence of the surface-energy. But in many cases, as with proteins, soaps and certain lipoids, the substance separates at the surface as a continuous solid film before this stage is reached. The formation of solid surface-films is hence highly characteristic of the solutions of such substances. Casein films form on warm milk, soap films form about droplets of rancid oil in the presence of alkali, and protein films about drops of chloroform or oil suspended in protein solutions. Thin solid membranes formed in this manner at phase-boundaries are called "haptogen membranes." In all of these instances we have to do with a surface-condensation, known under certain conditions as "adsorption," of substances which lower the surface-tension at the phase-boundary. Among the colloidal constituents of protoplasm the proteins and the lipoids belong to this class of substances. Hence it is not surprising that isolated portions of living protoplasm should delimit themselves by membranes. The vari-

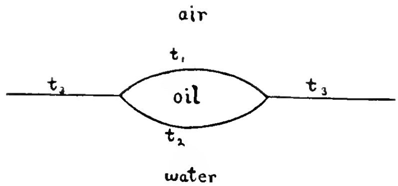

Fig. 1.

ous cell-membranes are to be regarded as essentially surface-films, or haptogen membranes. Not only do such thin films form about the reconstituting nuclei of dividing cells, but they are also deposited about various cell-inclusions, and even about division-spheres, chromatophores and other cell structures under certain conditions. It is well known that portions of protoplasm cut off from living cells—such as egg-cells, protozoa, root-hairs, etc.—exhibit the same osmotic properties as the intact cells, showing that new semi-permeable membranes are quickly formed at the cut-surfaces.

The surface of contact of the living substance with its medium thus becomes the seat of deposition of certain protoplasmic constituents or products which form membranes, often of a high degree of impermeability. This impermeability is a property of fundamental physiological importance. Speculation on the evolutionary origin of living cells usually leads to little result, but we may at least infer that the early protoplasmic systems which survived and became the ancestors of living organisms must have consisted in part of colloids like proteins and lipoids which had the property of forming surface-films sufficiently impermeable to limit or prevent free diffusive interchange with the surroundings. Only systems thus isolated to a sufficient degree from the surroundings could preserve the requisite complexity and constancy of composition, and hence be enabled to develop the properties of so-called living beings—properties which are so widely different from those shown by other natural systems. The surface-films, or plasma-membranes, of living cells at the present time are in fact typically characterized by a remarkably high impermeability to simple crystalloid substances like sugars, neutral salts and amino-acids, all of which are important constituents of protoplasm. Zangger expresses the situation concisely when he says that living cells can contain as permanent constituents only such substances as are not free to diffuse into the surrounding medium. The existence of this diffusion-preventing or insulating surface-film, the plasma-membrane, is thus a necessary condition of the stability of the living system and hence of the continuance of the life-processes. The living condition is in fact incompatible with marked and permanent increase in surface-permeability. During life the semi-permeable condition is retained; on death there is always a marked increase in the permeability of the plasma-membrane; the cell then undergoes a ready and rapid dissolution or cytolysis, and the constituents serve as food to bacteria. It is probable that the various intracellular membranes—nuclear membranes, vacuole-membranes, sphere-membranes, chromatophore-membranes—subserve a similar insulating or differentiating function. Hofmeister has indeed conceived of the protoplasm of living cells as subdivided in this manner into a many-chambered system, which accordingly permits of a high degree of chemical differentiation. A variety of independent processes

might coexist side by side in such a system, as appears, for example, to be the case in liver-cells; in this way a "chemical organization," distinct from and yet dependent upon a structural organization, becomes possible.

Haptogen membranes formed thus by deposition of proteins at phase-boundaries may show considerable density and impermeability. The protein in such surface-films may undergo an alteration resembling coagulation, assuming a relatively resistant and insoluble form, Thus Ramsden was able to coagulate protein solutions by prolonged shaking, and Robertson obtained thin films of coagulated casein, gelatine and protamine at the surface of chloroform droplets. Solid films of albumose, saponin, and other substances are formed at the free surfaces of their solutions—the readiness with which such solutions are thrown into foams depends in fact on this condition. The condensed and insoluble protein films formed on chloroform droplets are strikingly similar in many respects to those visible at the surfaces of cells like sea-urchin eggs, and which apparently correspond to the outer layer of the true plasma-membranes.

To come now to more directly biological considerations: what is the nature, chemical and physical, of the surface-film of living cells? There are few direct chemical analyses bearing on this question. Liebermann found the vitelline membrane of the hen's egg to consist largely of a keratin-like albuminoid. There is good reason to believe that modified proteins belonging to this class enter very generally into the composition of the surface-films of cells. The tendency to deposit horny or albuminoid material at the cell-surfaces is in fact remarkably widespread in animals. Cuticular and epidermal structures, to which chemical resistance and impermeability are physiologically essential, consist typically of proteins belonging to this class; such proteins have recently been called "scleroproteins" on account of their frequent presence in skeletal or cuticular structures. They are also abundant in the intercellular materials of bone, cartilage and connective tissue. The surface-films of many cells apparently have this composition. Thus in echinoderm eggs the characteristic fertilization-membranes, which Professor Jacques Loeb has shown to arise by separation of a surface-film, consist apparently of modified protein. They are at least non-lipoid in character and are remarkably resistant to reagents, resembling in these respects the protein films formed at the surface of chloroform droplets. The fertilization-membrane, after separation from the cell, proves however to be much more permeable than the true plasma-membrane, or semi-permeable external layer of the unaltered egg, so that it probably corresponds to only a portion—probably the outer layer—of this membrane. The presence of protein in the plasma-membrane of sea-urchin eggs is also indicated by the fact that the cytolytic action of

acids may be lessened or counteracted by neutral salts like sodium or calcium chloride. Such antagonistic actions between acids and salts, while not shown by colloids in general, are peculiarly characteristic of certain proteins. Thus the rate of swelling of gelatine (a typical scleroprotein) in water is greatly increased by the addition of a little acid; this effect is prevented by the addition of neutral salts, and the basis of this form of anti-cytolytic action may possibly lie here—*i. e.*, the disruptive action of the acid on the proteins of the membrane is checked or prevented by the salt.[1] Yet the plasma-membrane undoubtedly contains other constituents, and among these the substances belonging to the group of lipoids appear to be fundamentally important. These substances, fat-like in their solubilities and colloidal in their physico-chemical character, are always present in cells. Much light has been thrown on their physiological significance by the investigations of Overton and his successors, which have shown that ready permeability to lipoid-solvents is highly characteristic of both animal and plant cells. Alcohols, esters, ethers, hydrocarbons and similar compounds, all of which are soluble in lipoids, enter living cells rapidly, in contrast to neutral salts, sugars, amino-acids—the chief crystalloidal constituents of protoplasm—which diffuse into resting cells (with unmodified plasma-membrane) either imperceptibly or with extreme slowness. Overton's results thus indicate that lipoids enter into the composition of the plasma-membrane. This is to be expected. The structure probably consists of a mixture of all those protoplasmic constituents which have marked effect in lowering the surface-tension of the cell-boundary. Lipoids are conspicuous among this group of substances. That they form part of the plasma-membrane is also indicated by the readiness with which the permeability and other properties of this structure may be altered by lipoid-modifying substances. Lipoid-solvents as a class, when present in certain concentrations, have a specific action in increasing, often irreversibly, the permeability of the plasma-membrane. In lower concentrations many appear to *decrease* this permeability. Their influence on irritability, which is probably a function of the condition of this membrane, also indicates their importance as membrane-constituents. Narcotic action is highly characteristic of lipoid-solvents, and there is good evidence that this action depends on an alteration of the plasma-membrane. I shall refer to this possibility later, in connection with the problem of the relation of membranes to stimulation. All of these facts taken together indicate very clearly that the colloids composing the semi-permeable surface-film of living cells consist of

[1] This consideration, however, is not demonstrative. The precipitation of lecithin by acid can be prevented by salts in concentrations which in themselves do not precipitate, as Handowsky and Wagner have recently shown. Lecithin, which seems always to be present in cells, probably forms an important part of the plasma membrane, in which case changes in its physical condition would influence the properties of the latter.

both lipoids and proteins, which are probably intermixed or combined in some characteristic manner and vary in their relative proportions in different cells, according to the specific constitution of the latter.

What are the chief peculiarities in the physical properties of these membranes, on which their physiological importance depends? Two properties appear especially significant. One of these is the semi-permeability which the membranes preserve during life, *i. e.,* the ability to transmit water freely while holding back dissolved substances. The other is their ability to undergo reversible changes in their permeability to such substances, either in the direction of increase or decrease. These changes of permeability may in some cells be very rapid; and there is evidence that this is especially the case with irritable tissues, and that the power of rapid response to stimuli is directly dependent on this peculiarity. How essential the semi-permeability of the plasma-membranes is to living organisms may be realized with especial clearness in the case of plants. In many of these organisms the rate of growth, the normal form and habit, and the characteristic movements and reactions are intimately dependent on the peculiar condition known as turgor, which is the expression of the outward pressure of the dissolved molecules of the cell-contents against the membranes which enclose them and which they can not pass. The diffusing molecules hence press against these membranes, often with the force of many atmospheres, and keep the cellulose cell-walls stretched and rigid. It is on this condition that the maintenance of the normal form often depends. The entrance of the water into the cell in growth is also largely due to this osmotic pressure. Thus the confinement of the molecules within the cells by membranes impermeable to their outward diffusion is an indispensable condition of the continuance of normal life-processes in these organisms. The same is true of animal cells, although here the condition of turgor is usually unimportant in itself. But, as we have already seen, the preservation of the normal protoplasmic composition in the case of any cell involves the prevention or restriction of any free or unselected diffusive interchange of materials between the cell and its surroundings. The semi-permeability found during life is the expression of the all-importance of this condition. We must therefore ascribe to the insulatory or semi-permeable character of the plasma membrane, not only the existence of conditions like turgor in plants, but even the very possibility of the existence of a stable or permanent chemical organization in any cell.

This being the case, it is not surprising to find that simple modification of permeability may profoundly modify many cell-processes. To take first a relatively simple instance: if the semi-permeability of the plasma-membrane is a necessary condition for continued life in any cell, it ought to be impossible to increase this permeability beyond a certain limited degree for any length of time without inflicting permanent in-

jury on the cell and eventually causing death. Loss of essential cell-constituents through the altered membrane would have this effect. Now there is evidence that a large class of injurious or toxic substances exert their destructive action by altering the surface-films of cells and permanently increasing the permeability. When this occurs in such a cell as a blood-corpuscle or a sea-urchin egg—which is normally in osmotic equilibrium with its medium—the cell first swells (an effect showing loss of osmotic equilibrium) and eventually dissolves or disintegrates, an effect known as cytolysis. Lipoid-solvents, like chloroform or ether, have this effect in concentrations above certain minima: they disrupt the membrane, presumably by altering the condition of the lipoids, and disintegration follows. Many toxic alkaloids and glucosides—like saponin, digitalin, aconitin, etc.—and certain bacterial products—cytolysins and hemolysins—have similar effects. Other substances, as inorganic salts, acids, or alkalis, may cause cytolysis by altering the state of the colloids of the membrane. In certain typical instances there is direct evidence that the toxic action is primarily due to a surface-alteration, and consists in a destruction of the semi-permeable properties of the membrane. Certain fluorescent substances like eosin exert a cytolytic action on many cells in the presence of light, though inactive in the dark (photodynamic action). Harzbecker and Jodlbauer found that blood-corpuscles so treated began to swell before there was any perceptible entrance of the dye into the cell, *i. e.*, the initial stage of cytolysis, involving a loss of osmotic equilibrium, occurred previously to the entrance of the toxic substance. But loss of osmotic equilibrium, unless soon reversed, involves destruction of the cell. The essential or critical toxic action in this case is thus superficial, and what is true of eosin is probably true of many other—possibly most—cytolytic substances.

The peculiar antagonisms existing between the physiological actions of various substances (*e. g.*, muscarin and atropin, toxin and antitoxin, etc.) are probably in many cases to be explained on this basis. The toxic and antitoxic actions of neutral salts form a case in point. Pure solutions of sodium salts, even sodium chloride, are strongly toxic to many cells, particularly those of marine organisms, as the work of J. Loeb and his successors has shown with especial clearness; but if to the pure solution a little calcium salt is added, this toxic action is prevented or greatly diminished; the calcium (or other favorable salt) counteracts the toxic action of the sodium salt—in other words, has an antitoxic action. Now it can readily be shown in certain organisms that the toxic action of the pure sodium salt solution is associated with a strong permeability-increasing action. As test-objects or physiological indicators in the investigation of these effects I have used the pigment-containing eggs of the sea-urchin, *Arbacia*, and the larvæ of a marine annelid, *Arenicola*, whose cells contain a water-

soluble yellow pigment. The eggs or larvæ die rapidly in pure isotonic solutions of sodium salts, and this toxic action is associated with a loss of pigment (more or less rapid according to the particular salt employed), *i. e.*, with a marked increase in permeability. But if a calcium or other antitoxic salt is previously added to the solution, both the permeability-increase (as indicated by loss of pigment) and the toxic action are prevented or greatly retarded. Apparently, a pronounced and persistent permeability-increasing action is equivalent to a toxic action; the calcium prevents or retards this destructive action of the sodium salt on the plasma-membrane, and hence has an anti-cytolytic or antitoxic effect. Professor Osterhout's experiments disclose similar conditions in plant cells; pure solutions of sodium chloride increase permeability—as shown by loss of turgor and increase of electrical conductivity—and have a well-marked toxic action; both of these effects may be prevented by adding a little calcium to the solution. In all of these cases the antitoxic action apparently consists in protecting the surface-film against the permeability-increasing action of the pure sodium salt solution. I have found that not only salts of metals, like calcium and magnesium, but also various lipoid-solvents or anesthetics may prevent the cytolytic action of pure solutions of sodium salts in an essentially similar manner. Evidently certain changes in the state of the lipoids in the membrane render the latter more resistant to the disruptive action of the salt solution. Cytolysis by substances like saponin may also be checked by neutral salts. It seems probable that the relations between bacterial cytolysins and anti-cytolysins are of the same essential nature. The theory of antagonistic salt-actions may thus become of the greatest importance as a guiding principle in practical therapeutics. Such surface-actions as those just described constitute only one form of toxic action, but they are among the most important because of the external position of the plasma-membrane in the cell and its consequent direct accessibility to modification by changes in the surroundings.

The integrity of the plasma-membrane thus appears to be essential to the normal living cell. Injury to this membrane thus means toxic action: prevention of this injury is antitoxic action; restoration of the normal permeability after injury is therapeutic action. But the plasma-membrane does not play only the purely passive rôle so far indicated. It is intimately concerned in many active cell-processes; and there is evidence that many of the distinctive energy-manifestations of the cell are determined or controlled by changes—largely changes of permeability—which have their seat in this structure. This appears to be true of many forms of cell-movement, of cell-division, and of the stimulation-process in general. Permeability-changes are also concerned in secretion, in the fertilization of the ovum, and probably in the general process of intake of food-materials by cells. The stimulation of irritable tissues is a process which exhibits a peculiarly intimate dependence on

the semi-permeable membranes of the irritable elements. Perhaps more is known of the relations of membranes to the stimulation-process than to any other cell-activity, and I shall accordingly consider its conditions in some detail.

There is evidence that a rapid and reversible increase in the general permeability of the plasma membrane is an accompaniment and indeed a primary condition of stimulation in irritable tissues. This evidence comes from many sides and is partly direct and partly indirect. Perhaps the clearest indications of this kind are afforded by the motile mechanisms of certain plants, like the sensitive plant (*Mimosa pudica*) or the Venus's fly-trap (*Dionæa*). In *Mimosa* the characteristic movement, which consists of a dropping of the leaves and a folding together of the leaflets, is due to a collapse of certain turgid cells which form the so-called pulvini, or cushion-like masses of parenchyma at the bases of the leaves and leaflets. A fluid containing dissolved substances rapidly leaves these cells on stimulation; evidently the membranes, semi-permeable during rest, become suddenly permeable to the osmotically active intracellular substances which maintain the turgor. This explanation—first put forward in its essentials by Sachs—is accepted by the majority of plant physiologists, and there is little doubt of its substantial correctness. We have here, therefore, an instance where stimulation depends directly upon a sudden increase in permeability. Now in this case the primary or critical change is apparently the same as in irritable animal tissues; an electrical variation similar to that shown by an active muscle or nerve accompanies the movement, and the conditions which call forth the response are essentially the same in the plant as in the animal. In the case of animals the evidence that increase of permeability is a condition of stimulation is, as a rule, less direct. Yet in certain organisms a sudden increase of permeability may readily be shown to be the equivalent of stimulation. My own observations on the pigmented larvæ of *Arenicola* illustrate this very clearly. When these organisms are suddenly brought from sea-water into pure isotonic solutions of sodium salts (*e. g.*, $m/2NaCl$) the muscles contract with extreme vigor and persistency, causing the larvæ (which are small worm-like trochophores about 0.3 millimeter long) to shorten to half their normal length; at the same time the yellow pigment contained in the cells of the organism diffuses into the solution and colors the latter yellow. The exit of pigment is the expression of a rapid permeability-increasing or cytolytic action; this is equivalent to a strong stimulation. If by the addition of any substance to the solution we check or prevent this permeability-increase, we find that stimulation is checked or prevented at the same time. Thus, if instead of the pure $m/2NaCl$ we use $m/2NaCl$ to which a little calcium or magnesium chloride, or other appropriate salt, has been added, the strong stimulation and loss of pigment are no longer seen—both are simultaneously

prevented. The same effect may be produced by various anesthetics; these also protect the cells against the permeability-increasing action of the $m/2NaCl$, and at the same time prevent stimulation. Thus, if *Arenicola* larvæ are exposed for a few minutes to an isotonic solution of a magnesium salt and are then brought into $m/2NaCl$, neither stimulation nor loss of pigment follows. The same is true if they are brought from ether-containing sea-water into ether-containing $m/2NaCl$; and other anesthetics in appropriate concentrations show a similar inhibitory and protective action. These and similar experiments point to the conclusion that a membrane-alteration, in the direction of rapid increase of permeability, is constantly associated with stimulation. It is of course apparent that such increase in permeability must in normal stimulation be perfectly reversible. If the reversibility is incomplete, permanent injury results; and this is in fact the case when *Arenicola* larvæ are stimulated by immersion in pure isotonic sodium salt solutions. We have already seen that this injurious action, as well as the stimulating action, is greatly diminished by the presence of calcium chloride, or some other antitoxic salt. Anesthetics also show an antitoxic as well as an anti-stimulating action.

It is impossible within the limits of this article adequately to discuss the physiology of stimulation. A few of its aspects ought, however, to be touched on here, since otherwise the above relation between permeability-increase and stimulation may appear as a merely empirical or detached observation, without any general or theoretical significance. The most striking physical peculiarity of irritable tissues is their sensitivity to electrical changes in their surroundings. Most persons are accustomed to think of electrical currents as laboratory phenomena *par excellence,* and as playing little part in nature outside of laboratory walls. Yet living cells are profoundly influenced by such currents. We can in fact imitate the normal conditions more closely by using electrical currents as stimuli, than in any other manner. This preconception is however a completely mistaken one. Not only do irritable tissues respond to electrical currents, but certain electrical changes in the tissues themselves are invariably associated with stimulation, whether normal or artificial, and form perhaps the most constant and essential feature of the stimulation-process. Such a statement may sound like a truism to any one versed even slightly in modern physical chemistry: ions—charged molecules and atoms—are present everywhere in protoplasm, and it would perhaps be surprising if electrical changes did not accompany protoplasmic activities. We have, however, to inquire more particularly into the nature and conditions of the response of irritable tissues to the electrical current, and of the electrical processes originating in the tissues themselves, and to relate these processes, if possible, to the total effects produced by stimulation.

These processes again, like some of those already referred to, appear to be a function of the changing permeability of the plasma-membrane. When we take a tissue consisting of a parallel bundle of cells, like a frog's sartorius muscle, cut it across, place one electrode in contact with the normal uninjured surface of the muscle, and the other with its cut surface, and connect the two with a galvanometer, we find that an electrical current passes—the so-called demarcation-current. The exposed interior (or cut surface) of the cells always shows a lower potential than the exterior; the potential-difference lies usually between a tenth and a twentieth of a volt. This potential-difference depends on the living condition of the cells. It is absent or insignificant in dead muscle. It diminishes when the muscle-surface is treated with cytolytic substances—*i. e.,* with substances which increase the permeability of the plasma-membrane. The evidence, in fact, indicates that the existence of a normal demarcation-current potential is dependent on the semipermeability of the plasma-membrane. When the permeability is artificially increased, the potential-difference is invariably diminished; its degree thus appears to be dependent on the degree of permeability of the membrane; hence its increase on death or under the influence of membranolytic substances. Now during stimulation the demarcation-current potential always undergoes a marked decrease; this is the change known as the negative variation or action-current, which is an inseparable accompaniment of stimulation. Normally, this change is completely reversible, and when stimulation ceases, the original potential-difference is regained. What is significant from the present point of view is that the *direction* of the electrical variation accompanying stimulation is the same as in that resulting from death or cytolytic action and associated with an increase of permeability. The phenomenon is thus intelligible on the assumption that during stimulation there is a sudden and marked increase in the permeability of the plasma membrane. This permeability increase, with the accompanying electromotor variation, differs from that associated with death or cytolysis chiefly in being rapidly and completely reversible. Stimulation may, however, be so excessive under some conditions as to lead to irreversible alterations in the membranes, or even to the death of the cell; *i. e.,* the degree of reversibility is limited, and this consideration explains why excessive stimulation is so injurious—it is in effect equivalent to a cytolytic action or any other action where permeability is irreversibly increased.

Why should a change in the permeability of the membrane produce electrical effects of this kind? The phenomenon becomes intelligible when we remember that membranes act by limiting or preventing diffusion, and that they may limit the diffusion of ions—the mobile, electrically charged atoms and atomic groups present in salt solutions—just

as they do that of uncharged molecules. The ions formed by the dissociation of any electrolyte have as a rule unequal diffusion-velocities, and presumably unequal solubilities and other physical properties, in correspondence with their chemical differences; and hence we may infer that they possess unequal abilities to pass through membranes. If this is so, a membrane separating two electrolyte-solutions becomes the seat of a potential-difference; *i. e.,* a potential-difference, which may be considerable, will exist between its opposite faces. This suggestion, first made by Ostwald in 1890, has formed the basis of the chief prevailing view—the so-called "membrane-theory" of the nature of the bioelectric processes. Ostwald's suggestion, modified to suit the conditions in cells, was essentially as follows. Imagine the cell enclosed in a plasma-membrane freely permeable to the cations (positive ions, *e. g.,* hydrogen ions or potassium ions) and impermeable to the anions (negative ions) of a certain electrolyte (which we may suppose to be lactic or carbonic acid) contained in the protoplasm (Fig. 2). The cations then pass outward, carrying their positive charges, while the anions remain behind; this will proceed until the potential-difference thus arising is sufficient to compensate the diffusion-tendency (equivalent to the osmotic pressure) of the cations. A condition of equilibrium with outer surface positive and inner negative thus results. The membrane becomes the seat of an electrical polarization (normal or physiological polarization) which is dependent on its impermeability to anions. If the permeability of such a membrane were to increase sufficiently to transmit the anions, a fall of the potential-difference between the exterior and the interior of the cell would at once follow. An effect of just this kind is seen in muscle and nerve during stimulation, and is attributed by Bernstein and other upholders of the membrane-theory to the changing ionic permeability of the membrane. The selective permeability to ions of different sign, on which the potential-difference between exterior and interior depends, disappears along with the general increase in permeability accompanying stimulation: hence a negative electrical variation is always associated with this process.

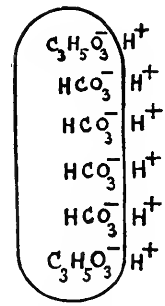

FIG. 2. Illustrating the supposed conditions of polarization of the plasma membrane. The electrolytes are lactic and carbonic acids; the membrane is supposed to be permeable only to H-ions.

The precise arrangement imagined by Ostwald has not yet been satisfactory realized, although, according to Brünings, precipitation-membranes of copper ferrocyanide show some of the properties required by this theory. But certain natural membranes present a much closer approach to the theoretical requirements; thus the surface-membranes of apples, which Beutner and Loeb have recently studied, behave as if

decidedly more freely permeable to cations as a class than to anions, and it is possible that this condition is typical for the plasma-membranes of cells. The membranes of irritable tissues, however, may belong to another type; certain membranes (consisting of thin films of glass) whose electrical polarization depends on the relative hydrogen-ion concentrations in the solutions which they separate, have recently been investigated by Haber; and in some respects the phenomena presented by these membranes appear to correspond more closely to the conditions in irritable tissues. Hydrogen-ions would be the polarizing cations in the case of these membranes; and in fact irritable tissues are as a rule remarkably sensitive to changes in the H-ion concentration of their medium. We are not yet in a position to decide between such alternatives. But for the present purpose it is sufficient to recognize that a membrane which interferes unequally with ionic diffusion may become the seat of a potential-difference when it separates two solutions; and the evidence that plasma-membranes and other cell-membranes are of this kind appears very strong, even at the present time. In general, phase-boundaries are the seat of electrical energies, and these largely depend on the ionic content of the adjoining media. Membrane-polarization is a special instance of this general class of phenomena. The precise conditions of the normal physiological polarization in irritable tissues have to be determined by future investigation.

Membranes in their electrochemical aspect are to be regarded, on the present theory, as *ion-transmitting* surfaces, just as the metallic plates in ordinary electric batteries are ion-forming or ion-combining surfaces. The electrical properties exhibited by all of these surfaces are conditioned in essentially the same manner, and Nernst's theory applies to all. A system composed of solutions separated by membranes may thus, under the proper conditions, show the same essential properties as a system of batteries connected in series. The potential-differences of the individual elements may be summed by appropriate arrangement so that the electric tension between the terminals may be very large. In the electrical organs of *Gymnotus* and other fish, systems of this kind have actually been realized in nature, and have been applied to defensive or other purposes.

Let us now consider in a little more detail the conditions of stimulation of an irritable tissue by an external electric current. The surface-film of the muscle-cell or the nerve fiber is to be regarded as electrically polarized in the sense already indicated. Why does the tissue respond in its characteristic manner to the electric current? The first fundamental suggestion as to the mode of action of the current was made by Nernst in 1899. He pointed out that the current in passing through a living tissue—a system equivalent to a solution containing electrolytes and subdivided by semi-permeable membranes—

can produce decided changes of condition only at the semi-permeable surfaces, where the movement of ions is blocked; changes of electrical polarization would be produced at such surfaces; ions of a given sign would be carried against one face of the membrane by the current and would concentrate there until the back-diffusion equalled the current-transport: the same effect, with the signs of the ions changed, would result at the other face (Fig. 3). He conceived that in electrical stimulation something of the kind occurs. The essential or critical change occurs at the semi-permeable membrane, and consists in carrying to this membrane sufficient ions to produce a given ionic concentration-difference corresponding to a given electrical polarization. This is the determining condition of stimulation. A certain time will be required for the process, depending on the strength of the current, and on the specific diffusion-rate of the ions. Nernst estimated that on this hypothesis the stimulating action (S) of a given current ought to vary directly with its strength (i), and with the square root of its duration (t) ($S = Ki\sqrt{t}$, K being a constant characteristic of the tissue). The experimental data show that a more intense current requires for stimulation a shorter time than a weaker current, and in approximately this proportion. The more recent work of Lapicque, Lucas and Hill has confirmed and amplified Nernst's theory. There is therefore strong evidence that a current stimulates by producing an electrical polarization at the membranes.

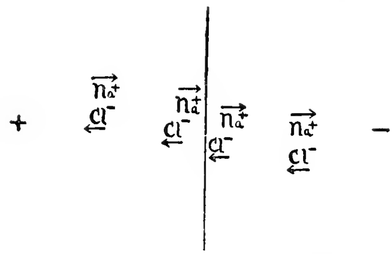

FIG. 3. Illustrating the polarization of the current on a membrane difficultly permeable to ions. The anions and cations of the electrolyte, NaCl, move in the direction indicated by the arrows. The current, passing from left to right, carries cations toward and anions away from the left face of the membrane; at its right face the conditions are reversed. The membrane thus becomes electrically polarized, with its left face at the higher potential.

During life, however, the membranes are apparently already the seat of a preexistent polarization, as we have seen. The polarization produced by the external current must, therefore, modify this. Now it appears that in most, if not all irritable tissues, stimulation results when the physiological polarization is *diminished* suddenly, but not when it is increased. This is the simple inference from the law of polar stimulation. When a current is passed through a tissue the external positivity of the irritable elements is lowered on the side directed toward the cathode and increased on the side directed toward the anode, as may be seen by reference to Fig. 3. Now it has long been known that the stimulus originates on the cathodal side of an irritable tissue when the current is made, and on the anodal side when

the current is broken; *i. e.*, we obtain stimulation when the preexisting polarization of the irritable elements is rapidly *diminished*—in other words, when there is a *depolarization*. We may formulate the essential relations thus: stimulation is equivalent to depolarization, *i. e.*, to a rapid decrease of the already existing or physiological polarization of the plasma-membranes.

Stimulation, however, is also connected with a change in the permeability of the membrane, as we have seen. We must therefore conclude—since a sudden change of polarization stimulates—that simple alteration of the electrical polarization alters the permeability of the membrane. Decrease of the potential-difference between the opposite faces of the membrane—*i. e.*, depolarization—apparently increases permeability, and often to a remarkable degree. Irritability seems, in fact, to be an expression of this peculiar relation. The electric current thus alters the polarization of the semi-permeable membranes of the irritable tissue, and in so doing alters the permeability. This change becomes the condition of the characteristic electrical variation of the tissue; the latter is self-propagating, and thus the effects of the local stimulus are transmitted to other regions of the cell. These appear to be the essential changes in the stimulation-process as such.

According to this point of view we must conceive of the plasma-membrane of an irritable element as possessing during rest a characteristic impermeability or semi-permeability to which corresponds a definite polarization, or potential-difference between its outer and inner surfaces, of the value of (*e. g.*) one tenth volt. Now the permeability of the membrane is determined by a number of conditions, some of which are, its chemical composition, the temperature, the chemical changes in the protoplasm and the surroundings, and probably the state of mechanical tension of the membrane. Another factor is, however, of fundamental importance: this is the existing state of electrical polarization of the membrane. Alteration of this polarization alters the permeability; if we decrease it we increase the permeability and stimulation may follow; if we increase it we presumably alter the permeability in the inverse direction—hence in all probability the lowered irritability at the anode (anelectrotonus) during the passage of a constant current through a muscle or nerve. Such a view ascribes peculiar properties to the plasma-membrane, but the facts lead directly to this interpretation. Girard has shown experimentally that changing the electrical polarization of a membrane of bladder or parchment alters the permeability to neutral salts. The electrical state of a membrane may thus determine its permeability. The plasma-membrane of irritable tissues has apparently acquired extreme sensitiveness to changes in its electrical polarization, such that slight electrical dis-

turbances in the surroundings may lead to a large increase of permeability, and hence to marked stimulation.[1]

On this hypothesis we can also understand why the state of excitation is transmitted from one region of the irritable element to another. It is highly probable that the effect of a local stimulation is propagated over the surface of the muscle-cell or nerve-fiber because of the electrical variation which the permeability-change at the excited region itself produces. This electrical variation affects the adjacent regions of the membrane, and alters their permeability, with corresponding electrical effects, and so the effect spreads. The explanation of the conduction-process in a nerve or other irritable tissue is on this view identical with that of the stimulation-process. There is, in fact, good evidence that the region in a state of excitation simply excites the adjoining regions electrically by means of its action-current, and that the effect is transmitted in essentially this manner.

It is possible to change the polarization of the membrane, and hence its permeability, in other ways than by passing an electrical current. Or we may alter the permeability directly, by acting on the cell by chemical substances, or by suddenly changing the temperature, or by mechanical action. When such treatment produces a sufficient increase of permeability, we may suppose that all ions become free to pass the membrane, and that a polarization-change then occurs, with consequent stimulation which, like other forms of stimulation, is self-propagating. On such a view the ordinary forms of mechanical and chemical stimuli are at bottom electrical in their nature. Such stimuli act by directly altering the permeability of the membrane and hence its electrical polarization.

On the other hand, the properties of the membrane may be so modified under certain conditions that it fails to respond to changes of polarization by changes in its permeability. This occurs, for instance, in narcosis. I have found that narcotics, in the concentrations at which they anesthetize the musculature of *Arenicola* larvæ, also check or prevent the permeability-increasing action of isotonic sodium chlo-

[1] The assumption of a permeability-increase at the time of stimulation is the only hypothesis, so far as I know, that accounts at once for the two characteristic and invariable accompaniments of stimulation, (1) the negative electrical variation, and (2) the temporary loss of irritability (refractory period) during the electrical variation. The time-relations of these two outwardly diverse phenomena coincide, as Tait has shown, and both are to be regarded as expressions or consequences of the same change, namely, a temporary increase in the permeability of the limiting membranes. This increase involves a temporary loss of the semi-permeability which is essential to the maintenance of the normal polarization of the membrane, and also—according to Nernst's theory—essential to electrical stimulation. I therefore regard the existence of a refractory period as furnishing strong support to the general theory of stimulation and conduction outlined above.

ride solution on the pigment-containing cells of this organism; at the same time they decrease or prevent the stimulating action of this solution. They also protect the organism against its toxic action, as we have already seen. An anesthetic action is thus the equivalent of both an anti-stimulating and an anti-cytolytic action. Both effects depend upon a modification of the plasma-membrane; under the influence of the anesthetic this structure becomes more resistant than normally to conditions that otherwise increase its permeability. We may infer in general that the degree of responsiveness of an irritable tissue is dependent on the state of its plasma-membranes; and that anesthesia corresponds to a condition of decreased susceptibility, and hyper-irritability to one of increased susceptibility, to the action of permeability-increasing agencies. Sensitization and desensitization, on this view, are primarily surface effects, dependent on alteration of the limiting membranes.

The polarization-changes accompanying stimulation may be extremely rapid in some cases. During the contraction of a man's voluntary muscle under the influence of the will, the existence of a rhythmical electrical variation with an average rhythm of about fifty vibrations per second has recently been demonstrated by the thread-galvanometer. The negative variation accompanying a single muscular twitch occupies from one hundredth to one two-hundredths of a second in a frog's voluntary muscle at ordinary temperatures; that accompanying a single nerve impulse lasts about one thousandth of a second; while more slowly reacting tissues, like heart-muscle or smooth muscle, show correspondingly slower electrical variations. On the membrane-theory the corresponding permeability-changes in the membrane must occupy similar times; and this consideration indicates the extreme delicacy of the adjustment between permeability and electrical polarization that must exist in the membranes of highly irritable tissues.

The electrical phenomena of stimulation are, however, relatively inconspicuous—if we except the case of the electric eel or torpedo. The characteristic and biologically important "response" of the tissue varies with its special nature. A muscle contracts, for instance; a gland secretes. The relation between the rapid change of polarization, which is the primary event in stimulation, and the resulting mechanical and chemical effects remains to be inquired into. The problem is a difficult one, and insufficiently investigated. The energy of muscular contraction is derived from the oxidation of energy-yielding compounds, like sugar. We must conclude that the polarization-changes at the cell-surface influence the chemical processes in the muscle-cell. Stimulation is known to increase many times the rate of oxidation in muscle-cells. I have lately attempted to modify the rate of formation of indophenol (a deeply colored organic oxidation-product) in the blood cor-

puscles of the frog by passing induction-shocks; and I find that the rate of formation of this compound through intracellular oxidation can be greatly accelerated by this means, especially in leucocytes, where the oxidation-rate is relatively rapid. I am inclined, therefore, to attribute to the variations in the electrical polarization of the membranes an important general rôle in varying the rate and possibly the character of the energy-yielding intracellular oxidations. On this view, intracellular metabolism would be largely controlled by membrane-processes. How this is possible may be illustrated by the case of anesthesia just discussed. The ether-impregnated plasma-membrane is relatively unaffected, as compared with the normal membrane, by isotonic sodium chloride solution; and consequently the stimulation, with its resultant increase in oxidation, is prevented by thus altering the membrane. The precise nature of the conditions in these and similar phenomena can be elucidated only by further study.

I had hoped to discuss the rôle of membrane-processes in other cell-activities, such as fertilization, cell-division and development, but the space at my disposal is insufficient. Before closing, however, I wish to refer briefly to the large class of physiological processes in which a regular rhythmical repetition of the same change, *e. g.*, contraction, is the essential characteristic. Such processes include ciliary activity, the action of contractile vacuoles, the action of the heart and of nerve-cells like those of the respiratory center or the heart-ganglia of certain animals. In the division of cells during early development, a definite though slower rhythm is also seen. Now an electrical rhythm accompanies the physiological rhythm in muscle and nerve cells, probably in cilia, and almost certainly in dividing cells, as indicated by the experiments of Miss Hyde on dividing fish-eggs. The existence of a chemical rhythm—of carbon dioxide production—has been demonstrated in dividing cells (sea-urchin eggs) by Dr. Lyon, and we may infer its presence in the other rhythmical processes. The electrical rhythm indicates a rhythm of changing permeability, and of this there is some direct evidence in dividing egg cells. In all of these cases we have to do with automatic processes whose rhythm proceeds of its own accord, provided the external conditions remain normal. Each cycle in the rhythm furnishes itself the conditions for its own recurrence. The question arises: from what physico-chemical point of view is it best to regard this class of phenomena? In the case of a rhythmical contractile tissue three interdependent and synchronous rhythms may be distinguished—a chemical, a mechanical (presumably the expression of surface-tension changes), and an electrical. An elementary model of these phenomena is, I believe, furnished by the experiments of Bredig and his pupils on the rhythmical catalytic decomposition of hydrogen peroxide in contact with metallic mercury. When a ten per cent. solu-

tion of hydrogen peroxide is poured over the surface of pure mercury, a film of peroxidate at once forms over the surface of the metal. Its formation alters the surface-tension of the mercury by changing the potential-difference between the metal and the solution. Consequently, the form of the mercury-surface changes. Under appropriate conditions this deformation causes a mechanical rupture of the film at some portion of its surface; there follows on this an electrolytic decomposition of the peroxidate at the margin of the fissure, an effect which spreads over the whole surface and involves the dissolution of the film, and its reduction to metallic mercury, together with the liberation of oxygen. The film then reforms, and the process is repeated. Thus a regular rhythm, involving a form-change, a chemical decomposition, and a change of electrical polarization, is started and continues automatically. The rate of rhythm may be altered, just as in organic processes, by altering the chemical character of the medium, *e. g.*, by changing its alkalinity, or by the addition of various other chemical substances. The velocity with which the film is laid down and dissolved may thus be influenced, and the whole rhythm correspondingly affected. Graphic records showing the variation in the rate of oxygen-liberation present a marked resemblance to the records of rhythmical organic processes like the heart-beat. Now the general conditions determining the rhythm in this phenomenon are strikingly like those which, on the foregoing theory of stimulation, determine the physiological rhythms. The surface-film of peroxidate may be compared to the plasma-membrane. Its rupture is equivalent to a local increase of permeability. This change is the direct condition both of the chemical change and of the electromotor change, on which last depends the variation of surface-tension conditioning the form-change. While the living system is indefinitely more complex than the mercury-peroxide system, yet in its rhythmical character and in the essential nature of the controlling conditions this automatic rhythmical catalysis bears an undeniable and striking resemblance to the action of living tissues like the heart, in which a rhythmical autostimulation is the distinguishing characteristic. In both cases an alteration of a surface-film is the critical change; and the rate of this change determines the rate of the other rhythmical events of the cycle. We may infer that if we could control the condition of the plasma-membranes of cells we could control the entire range of cell-processes. But I do not wish to prejudge these questions; I make the above comparison chiefly in order to suggest possibilities, and to indicate the desirability of devoting more careful study to the surface-films of cells. Investigation of the conditions of their formation, their permeability and their physical and chemical nature is certain to lead to results of far-reaching importance for biology.

THE PROBLEM OF THE EFFICIENCY OF LABOR

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IT may truthfully be said that industrial evolution is little else than the progressive development of economic efficiency, and the various stages in the story of the evolution of industrial society have been largely based upon man's control over nature as indicated by his industrial efficiency. The transition from one stage to the next has ofttimes been imperceptible; at others it has been very marked. The modern period, with its great aggregations of capital and its machine-made products, is so far superior to the handicraft stage that comparisons are made merely for the sake of measuring that development. Yet even before we are thoroughly accustomed to the change, significant facts are presenting themselves which would seem to indicate that we are on the verge of still another era of industrial expansion. And though it is always rash to prophesy, yet it may be safe to say that the effect of this transformation upon society in general and especially upon the relation of employer to employee, will be far greater than we may at first think. This much at least seems certain, that tremendous strides are about to be taken *from a purely productive point of view* which will at the same time materially affect the condition of the working classes.

If we eliminate from consideration the element land, and we may safely do so in the present discussion, the production of wealth is the result of two factors, labor and capital, both of which are more or less variable in character. The development of modern power-driven machinery has in recent times been remarkable, and no one would for a moment maintain that the end is in sight. Greater care in the construction and location of mechanical devices already invented will immensely increase their efficiency. Yet it is very questionable if in the future any such radical changes will occur as were witnessed between 1750 and 1850. Perhaps, indeed, it was because of that progress that attention has been in the past chiefly centered upon man's control over nature through the means of mechanical devices. Be that as it may, this much can scarcely be contravened, that those engaged in the active work of production (as well indeed as many theorists) seemed until very recently to have forgotten that capital in the form of machines is only one of the factors upon which the production of wealth depends.

The reason for this undue emphasis is not far to seek. As has been suggested, the enormous strides which have been taken in the invention and development of various forms of power and of labor-saving machinery has in itself, no doubt, been a potent reason why the labor factor should temporarily be neglected. Moreover, the universal confusion among practical men of affairs between labor and capital undoubtedly helped to obscure the importance of the former. Even to-day the manufacturer is prone to place his labor supply in the same category as his supply of raw materials, and to think no more about it than to be sure that there are men enough to run his machines and to do the work demanded. To the consideration of the relative cost and efficiency of two machines he will give hours; to the choice of men to run the machine he will devote scarcely ten minutes. It is these and similar facts that have lain at the bottom of the failure to appreciate properly the importance of efficiency of *labor* as contrasted with the efficiency of machines. Not that labor unions and the backers of progressive labor legislation have been negligent, but their work lies in the main within the scope of the last half or even quarter century, and their labors are just beginning to bear full fruit. As one of our great railroads says to its employees in a recent bulletin:

> There are so many things of the past, so many things of the present, to persuade us to the opinion, if not indeed to the assumption, that man has been so intent upon improving and developing and helping toward perfection the things over which he was given dominion in Eden that he has left the matter of his own intelligently directed evolution until the last.

The result of all this has been that even up to the present, though to the standardization of nearly everything in the mineral and vegetable kingdoms and a goodly portion of the lower orders in the animal kingdom men have worked with earnest and often enthusiastic cooperation, when it came to standardizing *men* and developing efficiency in them, there has existed a confusion and lack of cohesion equal to that of Babel. Efficiency in machinery has been taken for granted by those interested in production, efficiency in labor has been largely overlooked until the modern efficiency engineer appeared upon the scene.

But times are changing, and men generally are slowly coming to realize the full significance of the term "labor efficiency." Part of this has been due unquestionably to the influence of labor unions. The increasing stress given by economists upon the distinction between labor and capital, as economic concepts, has not been without its effects. The natural and inevitable failure of mechanical invention to keep abreast of the pace set at the outset of the industrial revolution has also served to detract attention from the purely mechanical aspect as soon as something else arose which demanded attention. To all this we must add the exhaustion of the frontier and the other influences

called attention to by Professor John R. Commons, which tend to strengthen and emphasize the labor problem generally.[1]

A moment's reflection will reveal the significance of this modern movement toward greater efficiency. When we realize that according to experts *only from 20 to 60 per cent.* efficiency has up to the present time been secured in the average industrial plant we are almost staggered when we think, not only of the effect that has been wasted in the past, but of what will be possible in the future when this energy is rightly directed in the actual work or production. In fact, it would seem that, were one half the effort and thought we make to secure efficiency in things outside of ourselves directed toward the securing of greater efficiency of human units, there would evolve within a few generations a race almost of supermen. So with the rise of those whose business it is to secure efficiency from *labor*—whose specialty is the gaining of cooperation, frankness and well-directed efforts through a study of what has been called "shop psychology" it is wholly possible, if not indeed probable, that a combination with mechanical efficiency may be affected that may well alter the entire aspect of industry, and, mayhap, usher in a new stage in industrial evolution.[2]

Treatments of industrial efficiency up to the present time have, in the majority of instances, been lacking for one of two reasons, either they have overlooked the very human instincts of the employer or they have assumed an inherent antagonism between the interests of the laboring class, as typified in unionism, and efficiency systems that could not be overcome. Let us examine efficiency systems from the point of view of these facts.

The apathy (or active opposition in some instances) on the part of many employers to modern systems of industrial efficiency may be traced to one of two causes. On the one hand, there frequently exists a confusion between low *individual* wage cost with low *total* wage cost. Or, on the other hand, the difficulty that has hitherto existed of measuring with any degree of accuracy the efficiency of individual workmen has undoubtedly worked against a more universal adoption of the plan. Each of these facts will bear some notice beyond mere mention.

The costs of a manufacturing concern may be roughly separated

[1] See also the writer's "Economic Basis of the Fight for the Closed Shop," *Journal of Political Economy,* November, 1912, especially p. 952.

[2] The truth of this statement will appear when the full intent of the measures to develop labor efficiency are considered. The efficiency engineer has more in mind than the mere invention of a new wage system—his work consists equally in securing good housing, relief from monotony, a fair living wage—in a word, in what may be termed social, labor legislation. The fact that he is interested from the point of view of the employer does not alter the significance of his work. More will be said of this later.

into (1) wages, (2) raw material, (3) operating expenses, (4) overhead charges. Taking these four items into account, the producer has, logically enough, proceeded on the assumption that the less he has to pay for any one of them, the selling price remaining constant, the greater will be his net profit. When in the earlier stages of industry, production was carried on in small workshops, and hired help was uncommon because unnecessary, the only direct costs were those for raw material and for overhead charges. The lower the price per unit the producer had to pay, the lower were his total costs of production. When he came to need help in the shop, he assumed, rather than figured it out, that the less he had to pay an assistant per day, the lower would be his wage cost. If the thing were true of raw material, obviously, he reasoned, it would also be true of labor cost. The fact that his help was trained and worked under his personal supervision and hence was actually more efficient than would otherwise be the case probably explains why the fundamental error in his assumption passed unnoticed.

When shops became factories and power-driven machinery replaced the old hand processes, the question of the competency of labor was never raised, for reasons already noted, save in unusual cases, and attention was centered upon capital. With their minds still on the mechanics of production, competing employers began to unite, and the modern concentration and integration of industry commenced. With its development, aided perhaps by those who had the time to analyze theoretically the costs of production, was evolved the monopoly principle of price, namely, that the price should be fixed at that point where the difference between the *total income* and the *total cost* was the greatest. And it was merely a question of time before some progressive individuals came to apply the same principle to wages and the labor cost. The added attention unionism had forced people generally to give to labor undoubtedly caused the idea to develop sooner than it would otherwise have done.

It is, however, in some respects a surprising thing that this principle has not come to have a more general recognition, since it is applicable in industries other than monopolies. In theory, it is almost universally conceded that the efficient man—he who produces most and best—is always the most profitable, even though he demands a somewhat higher wage. The truth of this statement has always been the reason ascribed for the successful competition of American industry with that of Europe, *despite lower wage cost per unit on the continent.* But employers have been prone to accept this greater efficiency of the American workman as a thing in the natural order of events, and so drew the conclusion that if he could get this greater efficiency at European rates, his profits would be doubly increased, failing utterly to see that *the efficiency largely depended upon the higher wage,* or, in

other words, that efficiency and low wage can not, in the very nature of things, be compatible. In America, the higher wage was for a long time a thing the employer could not avoid, but in Europe it could be avoided. The recognition of the principle and its application to practise has hitherto been left to Germany, who has clearly demonstrated in her mills that it is "the improved workman who is accountable for efficient workmanship," and that it is the totality of the effect of this fundamental economic and educational movement that has brought Germany to the front in the present industrial competition. Dr. Eliot has put it:

> We now know that the most efficient labor and the cheapest in proportion to its product is found where the laboring classes live comfortably, are well housed and fed, develop their intelligence and widen their prospects. The cheapest labor is no longer considered the most profitable.

Unfortunately, Dr. Eliot's conclusion is, though inevitable, somewhat premature so far as the United States is concerned, for it is still largely the rule in practise, though not in theory, to confuse low labor cost per unit with low total cost. Happily, the theory is becoming more and more the practise, and it is well, unless we are willing to be hopelessly outclassed by our neighbors in the competition for the world market.

There is, however, another factor, and one for which the employer is not so directly responsible, that assists in explaining why modern efficiency systems are not more universally adopted. This is in the fact that until quite recently no means has been available by which the employer could with any degree of accuracy measure the relative efficiency of men or of various systems of organization. The employer, of necessity, has paid one scale of wages to one class of workmen, because, as a rule, he had no means of gauging the amount of work of each man. It is exceedingly difficult to determine exactly what each of a number of workmen does each day, and even if he does know, the difficulty of comparing them is very great unless the work done by each man was of the same nature and done under the same conditions. The result has been that the employer has kept no individual records, and instead treats all workmen of a class as equals, and pays them the same wage. There may be 20 per cent. who are more efficient than the rest, but he has no means of distinguishing them from the others with any degree of accuracy. The result is that he declines to increase the wages, or makes such increases so small as to be insignificant as compared with differences in efficiency. In hiring men he offers the wage for which he can obtain the cheapest man, and if the good man stands out for a higher wage, he usually gets none at all. If the efficient man is to get a higher wage, his entire class must get it, and then the employer is paying the men more than they are worth. If the efficient

workman be a unionist, he must, if he be consistent, slacken his pace to that of the poorer one's, and hence in such shops the employer usually gets the efficiency he pays for. The question, therefore, which must be settled before all others, if the efficiency scheme is to be adopted, is: how shall differences in efficiency be measured?

Obviously to base a wage scale upon mere personal judgment as to the relative efficiency of men working within a shop would be out of the question, not only because it opens the way for charges of personal favoritism and consequent labor difficulties, but also because the complexity of modern shops would make such a plan physically impossible. The introduction of the simple piece-work plan was hailed as a great advance, as it unquestionably was from certain points of view, but here, too, failure was inevitable. Pace setting with the regular "trimming down" of wage scales was certain to produce bad feeling amongst the men, if no worse evils resulted, which was improbable. The workmen, too, were held responsible for all errors, which is obviously unfair—and bad policy for the employer, besides. Moreover, the plan is based upon a fundamental fallacy, namely, that a just scale of wages based on piece-work can be made which will at all times and under all conditions be just. The universal objection on the part of labor unions to simple piece-work has both theoretical and practical justification.

In view of these facts, modifications were suggested, notably in the Halsey, Rowan, Emerson and Taylor systems.[3] Space does not permit a discussion of the relative merits of these systems, even though it might fall within the scope of this article. Suffice it to say that a scheme had to be devised of accurate, concise individual records that could be used so as to be fair to the employer, yet that should recognize and encourage the good workman while it did not discourage the poor one. This has been done after considerable experimentation by efficiency engineers, and has proven satisfactory. The Holerith Service Requisition card[4] is a fair sample of what can be done along this line, and makes it possible to measure relative efficiency of workmen, not only with each other, but with whatever standard existing conditions justify.

We are now in a position to consider the other side of the question. What is the attitude of the laboring man to these efficiency schemes? It must be admitted that so far as organized labor, at least, is concerned its opposition is almost universal, and that this opposition has been the source of much criticism. Two questions naturally present themselves at this juncture: why does unionism oppose the efforts of the efficiency engineer, and second, what will be the ultimate outcome of such opposition? Let us consider these queries in their logical order.

[3] See Bender, "Systems of Wages and their Influence on Efficiency," *Engineering Magazine*, 26: 498.

[4] See *Engineering Magazine*, 36: 820.

The opposition of unionism to efficiency schemes is based upon two facts; the persistence of bad economic theory and the remembrances of bitter experiences. The theory that the various methods of restrictions of output, such as the refusal to follow pace-setters and the like, will make more work for other unionists has long been held by the ardent union followers, and the Bureau of Labor has said that the idea is almost universal among laboring men, whether members of a union or not.[5] The fallacy of such a doctrine has long since been exposed, and needs no repetition here. A more fundamental error, and possibly the real source of the one just mentioned, is the failure to recognize that wages are paid from total product and that labor's share in the national income is proportional to its share in the production of that income. The old wage fund doctrine still lingers. But unless we do entertain that abandoned theory it is difficult to escape the conclusion that increased efficiency results in added product and a consequent higher wage scale. This much at least is true that, as society is at present constituted, the laborer can not in the long run get more wages unless he also produces more.

Doubtless, however, the chief source of difficulty between the unionist and the efficiency advocate grows out of the experience of organized labor in the past with piece-work, bonus and premium plans; nor can it be said that the unionist is to be greatly blamed for being suspicious. The practical (and it has sometimes seemed almost inevitable) consequences following the institution of these plans in the past are too well known to be repeated here. The horizontal cut in the wage scale following what the employer has termed the earning of "excessive bonuses," time after time has made unionism perhaps unreasonably wary of all like schemes in the future. Be that as it may, this fact remains, that after having been trapped into being compelled to work at a killing pace to earn a decent wage, organized labor, pointing to this experience, objects to the point of desperate struggle the adoption of any form of "wages on the basis of efficiency" without giving them the chance even of a trial. Note the attitude of the Metal Polishers Union at the Rock Island (Illinois) government arsenal toward the introduction of the Taylor cards.

Unquestionably, the crux of the whole matter is in the relation of these efficiency schemes to the laborer and their effect upon him. Some writers have argued that since unionism is primarily interested in high wages, and the employer in low costs of production, that unionism and efficiency are inherently antagonistic. Others contend that because of its persistent fight against it, unionism will eventually compel industry to adopt "democratic measures" just as the evils of standing armies

[5] See Report of Bureau of Labor on Restriction of Output (1904).

compel nations to arbitrate their differences. Still others maintain that the most effective weapon against unionism is the proper reward of efficiency, since by that means all reasonable discontent is quieted. Thus H. L. Gantt in an article noted above says:

> If you keep an exact record of what each fellow does, surround the men with conditions under which they can work at high efficiency and compensate the efficient one liberally, no man will spend his spare time trying to find out how to raise the wages of the other fellow. Workmen as a rule will do more if their earnings are increased by so doing, and you will have great difficulty in getting the efficient ones into the labor unions if they are not benefited by joining.

In passing judgment upon these criticisms, two facts stand out preeminently before the thoughtful student of this question. The first is that some kind of an efficiency system, constructed upon a cost basis, is to become inevitably an integral part of the industrial organization of the future. Men may be apathetic about it, mistakes will be made in its application, labor unions may strive against it, but it is as inevitable as the industrial revolution. Time was—and traces of the spirit still linger—when labor organizations struggled against the introduction of modern labor-saving devices. The Knights of St. Crispan might unite against the use of pegging and sewing machines in the shoe industry; printers might protest against the introduction of the linotype, but it was of no avail—these things were a part of industrial evolution—*they increased man's efficiency in production,* and they could not be stayed. Exactly the same thing is true of modern efficiency systems—attention has been shifted from capital to labor, but the result will be the same. The employer demands it because his profits are thereby increased; the efficient laborer demands it because it increases his compensation and he feels, rightly, that superior skill should be rewarded; and society as a whole demands it, because in its totality it tremendously increases social wealth and welfare. The sooner unionism recognizes this fact and acts accordingly, the better it will be for its cause, both directly and indirectly. For we are loathe to admit that labor and capital are, and must remain, inherently antagonistic.

The second fact that requires recognition is that no plan which tends to increase the dependence of the laborer upon the employer or that fails to take cognizance of the real, vital well-being of the employee can in the long run prove successful. Because of this, it is essential that the employees in their collective capacity be given a voice in the direction of the shop. With human nature as it is, the temptation to cut piece-rates, to speed up machinery, and the utilization of similar methods must be, so far as possible, removed. In time the employers will undoubtedly come to see that the lack of hearty cooperation that

must be expected from men who are driven instead of led will wreak its own evil consequences, but in the meantime something else must be substituted. The details must needs vary with the individual shop and trade. It is necessary, however, that in some manner the employees in their collective capacity be recognized. From this point of view the plans of the Pennsylvania Railroad, the United States Steel Corporation and the National Biscuit Company, who offer a limited stock to their employees at reasonable prices, are weak. Few men can buy a sufficient quantity of stock to insure an effective interest, or if so, they can not hope to exercise the faintest semblance of influence upon the policy of the concern. The plan of the William Filene Sons' of Boston is far better. According to it the employees have a permanent shop committee, with certain privileges of recommendation regarding shop condition, methods of manufacture, and so forth, to a similar committee representing the employers. A combination of these two plans would undoubtedly be still more satisfactory wherever practical. Nothing is better established than that arbitrary, dictatorial methods on the part of the employer are fatal to the real interest and cooperation that an efficiency system demands. Such an attitude can result in nothing else than suspicion and antagonism. Whatever plan be adopted, therefore, it is essential that a channel be provided through which the workmen can express themselves.

It will be seen, therefore, from what has been said up to this time, that the question of efficiency is a far more complex one than appears at first sight. Perhaps, indeed, the efficiency expert is himself not entirely blameless in the matter, in that he has seemingly placed undue emphasis upon some system of *wage payment* and not enough upon the deeper significance of such a reform. For after all the introduction of some new plan for paying wages is but a superficial thing, if considered by itself. True, output may be tremendously increased by artificially stimulating the workmen through some form of piece-work; "speeding" increases output, despite the fact that it also kills men. The permanent, vital results of efficiency schemes appear after a man's wages have been increased as a result of added output. It is the things a man buys with his increased income and the improvement in his environment which it makes possible that constitutes the real basis of efficiency. Additional wages are of no value unless they bring to the earner better food and clothes, better housing conditions, relief from the monotonoy of factory toil, reasonably safe and sanitary places in which to work—in short, unless they mean a higher standard of living.

There is probably no efficiency expert worthy of the name who does not realize all this or who does not appreciate its full significance. It

is probably equally true that he does not strive for these things out of any consideration for the employee, but rather because it increases production. He sees, however, that the one necessarily implies the other. His first step in the attainment of his end has been the invention of a new system of wage payment, and he has been increasingly successful in this direction. But in doing so, he has so far neglected to purposely emphasize the *ultimate* aim that his critics have lost sight of it altogether. The result is that in many instances the unionist fails to understand his motive, and the employer does not see its necessity.

The problem of the efficiency of labor is therefore but a phase of the far wider problem of distribution. What the advocates of labor legislation and reform are striving to do from the point of view of the wage-earner, the efficiency expert is endeavoring to secure, though he may not realize it, from the standpoint of the employer. It would be well if this fact were more generally understood, for then the difficulties would be solved the sooner, and there would be less working at cross-purposes. And, after all, it is as Theodore Roosevelt said recently at Columbus:

> We have no higher duty than to promote the efficiency of the individual. There is no surer road to the efficiency of the nation.

BERGSON'S VIEW OF ORGANIC EVOLUTION

By Dr. HERVEY W. SHIMER
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THE French philosopher Henri Bergson has most appropriately chosen as the title of his book on development the name "Creative Evolution." As the name implies, to the inevitableness, the invariability of evolution as developed through physico-chemical laws, this philosophy adds the spontaneity, the indetermination of creation. The English translation of this book by Arthur Mitchell is a masterpiece of such work, and he is to be highly commended for the sympathetic manner in which the translation has been carried through.

All views of evolution divide naturally into two groups, the *mechanistic*—that all life can be accounted for through the application of the laws of physics and chemistry—and the *vitalistic*—that while the laws of physics and chemistry explain much, they do not explain all. The principal radical views of these two groups are the following:

Mechanistic	Neo-Lamarckian. Neo-Darwinian.
Vitalistic	Creative Evolution (Bergson). Teleology.

The Neo-Lamarckians hold that characters acquired during the lifetime of an individual are transmitted to its offspring. The Neo-Darwinians deny this utterly, holding that the germ cell, the reproductive tissue, is set apart for its generative work while the animal is in its embryonic state, that is, the reproductive tissue is not the product of the animal's own soma cells, but of its parents' germ cells. This school of Neo-Darwinians explains evolution by the theory that the germ cells are continually changing in every possible direction permitted by their stage of development and that those of these changes shown forth in the adult animal or plant which are beneficial to the organism are selected by nature for preservation. To the adherents of the former school, environment gives rise to variations; to the adherents of the latter it merely selects. To the former the long neck of the giraffe is due to the necessity that successive generations get their food from higher and higher bushes, a process of stretching illustrated by the animals in Kipling's "Just So Stories"; to the latter, those changes in the germ cell leading to neck elongation in the adult were selected by nature in times of drought.

Teleology in its most radical form holds that life is carrying out a

pre-arranged plan, that at the beginning everything was determined in detail and that all life is now following out the lines of that plan. Comparing this with the other two theories, the rabbits have long hind legs according to the Neo-Lamarckians because of the exercise they received when running to escape the fox; their ears likewise became longer because of the intentness with which they must guard against enemies. To the Neo-Darwinian the elongate ears and hind legs are due to changes in this direction in the germ cell, which changes nature selected by means of the fox who ate all individuals failing to make this change. To the teleologist it was planned in the beginning that as the fox became swifter the rabbit should likewise become swifter and more acute of hearing so that a proper balance should always be preserved between them.

Bergson's view of creative evolution is vitalistic in that it, with teleology, postulates a psychical force, which he calls the life impetus. But it differs from teleology especially in its belief that life is not bound by any prearranged plan, that it is free at all times to modify its course, to change its direction. Life, according to this view, is like a shell bursting as it flies, each fragment again bursting, and so on. The life impetus is thus continually dividing. Just as the way a shell bursts depends both upon the explosive force of the powder and the resistance of the metal surrounding it, so the direction of life depends upon the unstable balance of tendencies which it bears within itself and the resistance it meets with from inert matter. It is as if the vital impetus were trying to graft on the invariableness of matter the largest possible amount of instability.

According to the view of creative evolution, then, environment is a force evolution must reckon with, but not its cause, as with the mechanists, while adaptation of the organism to its environment will explain the sinuosities of the course of evolution, but not the general direction and still less the cause of the movement itself.

The problem confronting this vital impetus as it enters matter is somewhere to gather energy with which to counteract the retarding force of matter. At the surface of this earth the most available source of energy is the sun's rays. So the problem before life was this—to store this energy in suitable reservoirs so that it could be drawn upon at any time and for any need such as movement or reproduction. It succeeded in this by causing the kinetic power of the sun's rays to break up the inorganic compounds into their separate elements and then recombine them into the potential energy of organic foodstuffs. At first, doubtless, an organism thus gathered for itself the energy which it later expended in free movements; this form may be symbolized in a crude way by the infusorian, *Euglena*. This organism expends kinetic energy in motion like any animal, but in addition to the ordinary animal

method of deriving potential energy from plant reservoirs it likewise stores up potential energy for itself by the direct action of the sun's rays on its chlorophyll. But in the course of higher development it was found that these two functions, that of storing up energy and its expenditure in free movements, were incompatible in the same organism. There thus opened out before the organism two lines of development, one of greater movement, but with all the hazard of an uncertain food supply, the other of fixity, but with a certainty of food supply; the former resulted in the animal kingdom, the latter in the vegetable.

Since, however, these two kingdoms are branches of the same life impetus each contains something of the other. The difference lies merely in the tendencies upon which each lays emphasis, while it leaves the other tendencies lying dormant. So that plants and animals can not be defined by mutually exclusive characters, but rather by the accentuation of certain tendencies. Plants take their food as a rule from the inorganic, animals from the organic; as a result plants are usually fastened to the earth, immobile; animals get their food through movement. As a consequence of this differing method of food getting the plant cell surrounds itself with a hard coat of cellulose through which external stimuli can with difficulty affect the organism, and there is hence made possible but a very slight consciousness. Since to the animal cell movement is essential to food getting, it can not completely encase itself in a hard external skeleton; it thus follows that external stimuli readily affect the organism and there is hence rapidly developed an ever higher type of consciousness.

Consciousness, as used by Bergson, is not limited to self-consciousness, but is the kind of consciousness that Jennings in his "Behavior of Lower Organisms" is inclined to believe is possessed by all animals from the highest to the lowest. Bergson relates it to mobility. "The humblest organism is conscious in proportion to its power to move freely."

The elements into which a tendency splits do not possess the same power to evolve. The truly elementary tendencies continue to evolve, leaving behind the residual, split-off tendencies. This is illustrated in the development of the plant kingdom, where it is the carbon-fixers which carry on the main line of evolution.

Along the animal pathway, three of the main branches are those of the mollusks, arthropods and vertebrates. During the middle Paleozoic all had run into the blind alleys of stagnancy, of torpor, since most forms of these phyla had become enclosed in a hard external skeleton; but before this condition had become universal, some of the arthropods assumed, instead of the hard external skeleton of the crustacean, the soft one of the insect, and among the vertebrates the armored fish gave place to the unarmored.

Bergson here makes one of his most suggestive contributions, for he makes intellect and instinct divergent instead of linear characteristics. Intellect is not derived from instinct, but they are both present in all life. The former is emphasized by the vertebrates, reaching its culmination in man; the latter is especially developed by the arthropods and finds its highest expression in the Hymenoptera—bees, wasps and ants. The awakening from torpor could be effected in two ways; life, *i. e.,* consciousness launched into matter, could fix its attention either upon its own movement or upon the matter it was passing through, and it would thus be turned either in the direction of intuition, or of intellect. Apparently, on the side of intuition consciousness could not go far; it found itself so restricted by its envelope that intuition had to shrink into instinct, *i. e.,* to embrace only that portion of life upon which its continued well-being depended. Instinct is a prolongation of the life principle (vital impulse). We call that the life principle which in a living body coordinates the thousands of cells to work towards a common end and to divide the labor of feeding, reproduction and preservation among them, but we call that instinct which causes the bees of a hive to work towards a common end, and to divide the labor of feeding, reproduction and preservation among them.

The most essential of the primary instincts are really vital processes. Instinct only carries further the work by which life organizes matter. When the little chick is breaking its shell with a peck of its beak it is acting by instinct, and yet it merely carries on the movement which has borne it through its embryonic life. When the digger-wasp, *Ammophila,* stings its caterpillar victim in just the right places to ensure paralysis without death it acts by instinct, it must not be considered to have any knowledge like that of the learned entomologist who would know the vulnerable places from the outside—from detailed observations of all parts of the caterpillar body. The insect's knowledge, instinctive, proceeds from its inner identification with the same life principle as that of the caterpillar—from a sympathy (in the etymological sense of the word) between the two organisms which teaches the insect from *within* the vulnerability of its victim, whereas the intelligence of the entomologist goes all around the caterpillar instead of entering into it, making itself one with it.

On the other hand, consciousness concentrating its attention upon the matter it was passing through succeeded in evading the barriers raised by it, and now in man, freed to some extent from matter, it can turn inwards on itself and awaken the powers of intuition which still slumber within it. Intuition as thus used is instinct that has become disinterested, self-conscious, capable of reflecting upon its object.

Bergson makes freedom the corner-stone of his theory. The vital impetus has for its goal the acquirement of an ever fuller volume of

free, creative activity. Man shows that forth in himself in the creation, improvement and pursuit of ideals. He follows no prescribed path; he is perfectly free to choose, except that he may not go contrary to the broad course of evolution, *i. e.,* the direction of flow of the vital impetus.

While consciousness (vital impetus) is thus creation and choice, it is also memory. Beings advance in time, treading, as it were, upon a carpet which they weave with whatever colors and texture they wish, but they are ever rolling this carpet up behind them and carrying it with them. Thus all of the past is preserved, though not indeed all as self-conscious memories. It is this whole past which, "gnawing into the future, swelling as it advances," Bergson calls duration. The biologic law of recapitulation takes cognizance of a part of this memory.

Thus instead of a finalistic or a mechanistic universe with its course known or foreseeable, Bergson postulates one creating itself endlessly along an indeterminable course, constantly enlarging with the volume of its past experiences.

THE ABILITIES OF AN "EDUCATED" HORSE

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DURING the last few years a number of "educated" horses have been prominently before the public, alike in this country and in the old world, and they have received enthusiastic praise from all sorts of people. Doubtless some readers of this article saw and admired Blondine, who exhibited his "marvelous" powers continuously during the Pan-American Exposition at Buffalo. Many distinguished people paid him a visit; and observing his performances, they went away to tell astounding tales of his intellectual acumen. The testimonies of men eminent in politics, in war, in business, and in the professions were daily published at the door of Blondine's pavilion; and the writer remembers reading the hearty commendations of this "educated" horse by President McKinley, Admiral Schley, and a long list of persons celebrated in various walks of life. The press of the country described the readiness and accuracy with which Blondine could add, subtract, multiply and divide large numbers; how he would interpret commands given to him, such as to take a handkerchief to a particular lady in a company; how he could spell words given him by members of his audience; how he could read simple sentences; and how he could perform other mental feats which we have been accustomed to think are impossible except for an intelligent human being.

Leaving aside the "educated" horses of other days and of other countries, it is the intention here to describe the intelligence of King Pharaoh, which has probably attracted more attention than any other horse of recent times. He has appeared before notable people and vast audiences in every section of this country. He has received unqualified praise for his abilities from newspaper and magazine writers, and from such persons as Ella Wheeler Wilcox, Governor Eberhardt, of Minnesota, and others of like distinction. His trainer, Dr. Boyd, of Columbia, South Carolina, claims that we have at last an animal with genuine human intelligence, as shown in his interpretation of oral and written language, his mathematical calculations, his reading of human character, and similar achievements.

The writer, who had made some observations respecting Blondine's powers as revealed in his exhibitions in Buffalo, was able to make an investigation of King Pharaoh's abilities in November, 1911. An educational convention was in session in Miles City, Montana. King Pharaoh with his trainer and retinue of attendants happened to be

passing through to the Pacific coast at the time. The train was halted at Miles City, and Dr. Boyd was asked whether he would permit the writer to make a test of King Pharaoh's reputed human intelligence, and he readily consented to this. It was stipulated that the trainer should first exhibit the horse in the presence of a body of twenty-five observers, these to be chosen mainly from the educators in attendance at the convention, after which the writer would take control of King Pharoah, and his trainer and care-takers should leave the building, so that they could not influence the horse in any way during his performances. These conditions were agreed to by Dr. Boyd.

King Pharaoh is a small pinto stallion. He has an unusually large head for his size. The trainer called special attention to this trait before beginning his performance with the horse. He also dwelt upon the remarkable success which King Pharaoh had had in all of his exhibitions. He mentioned the people of prominence who had "studied" him, and who had commended him, putting special emphasis upon the testimony of Ella Wheeler Wilcox and Governor Eberhardt. Whether the trainer intended it or not, it was apparent that his remarks predisposed the observers in the horse's favor. One could see that they were much interested in King Pharaoh's large head, which indicated, of course, in accord with popular belief, that he *must* be intelligent. "Large head = superior intelligence" is the simple logic of the uncritical observer; and such a person will be partially convinced before he sees the horse in action at all. Then when great men, no matter in what department they may have achieved distinction, testify in favor of anything, the majority of people no longer maintain a genuinely critical attitude toward it. This is the result which the trainer must have known would issue from his remarks, though he may not have made them for this explicit purpose.

It should be stated at this point that the trainer had carefully arranged the setting of the stage before King was brought in. He had placed a blackboard on an easel; and at four or five yards to the left there was a rack ten feet long on which could be placed in upright position ten letters or ten numbers printed on blocks that could be easily knocked down. The letters and figures were printed on both sides of the blocks, so that the horse and the trainer could see them, and the audience could also observe them. Throughout the exhibition the trainer stood between the blackboard and the rack so that the horse would always be in front of him, and he could see what was taking place.

For the first experiment, the writer put on the blackboard the following figures

$$\begin{array}{r} 8\ 5\ 7\ 6 \\ 6\ 3\ 9\ 4 \\ \hline \end{array}$$

and said to the horse: "King, add these figures." The trainer then said: "King, do as the gentleman bids you. Go to the rack and show what is the sum of the first two figures. Go along and do it quickly." Then turning to the audience he remarked: "King is mischievous to-day, perhaps because it is so cool, and he may not do just as he should unless I compel him to. Usually I never have to take a switch to him, but sometimes when he is too mischievous, I have to correct him, and urge him to attend to his business." It was interesting to note the effect of this statement upon the observers. It put them at once into sympathy with the horse, and predisposed them to explain King's lack of responsiveness and his mistakes to his "mischief," and not to his inability to understand what was wanted of him. The remarks served effectively to divert many of the observers from studying the commands and actions of the trainer as possibly affording a clue to the reactions of the horse. They just naturally concluded that so much talk by the trainer was necessary in order to control the horse's "mischief," and it did not occur to them that verbal clues were mixed in with the commands.

Meanwhile the horse was standing at the rack without indicating any interest in the proceedings. He was not "studying" the figures on the board. He did not appear to understand what Dr. Boyd was saying about him. At least it was impossible for the writer, who was carefully noting King's reactions at short range, to detect any recognition on King's part of the trainer's remarks or commands, though it was claimed he understood every word. Turning to the horse again the trainer said, "King, why don't you do as the gentleman asked you? Find the first number. Come on, behave yourself, and find the first number," and he picked up a stick as if to slap him. The horse then walked over to the rack on which the number 10 had been placed near the lower end. He moved down to this number, and pushed it off. However, just as King came to the number 10, the trainer said, "Show the gentleman what the first number is." After having pushed off the right number, he pushed off the number 6 which was next to it. The trainer then said, "What is the number you carry? Find the number which you should carry." The horse moved along the rack, and while the trainer was talking to and commanding him, stamping occasionally to impress King with the necessity of "cutting out" his "mischief," he pushed off the number 1 and the number next to it. Then the trainer said, "What is the next number in this addition? Find it for the gentleman." The horse moved along the rack, and at the command, "Show the gentleman," he pushed off the number 13, and the one next to it. The trainer then had some one in the audience put the number 1 on the rack, though it could not be determined whether the horse was looking at the moment; and being commanded to show the

number which should be carried, King moved up to the rack, and apparently went directly to the right number, and pushed it off.

So he went through with the entire addition, making no mistakes, except that for most of the numbers he pushed off both the right one and the one next to it. The trainer in each case would take two or three steps toward him and say, "He knows perfectly well what is right, but he is mischievous to-day. Sometimes he does that, but very rarely." Then the trainer would call out to the horse, "King, if you do not behave yourself, I will whip you for it. Now you go and do as I command you." The effect of these remarks on the observers was evident; they were siding with the horse in all his "pranks," though he appeared to be in earnest, according to equine standards. The writer could detect no evidence of "mischief" in the horse's expression or action. But the observers showed sympathy with King, and delight in his evident intelligence. The writer, who did not participate in the demonstrations of admiration when King pushed off the numbers, was said by certain of the observers to be rather cold and blasé in regard to "educated" horses. One newspaper reporter who was in the audience told the writer later that he thought King would have done much better than he actually did do, if he (the writer) had not been eyeing him so coldly and unsympathetically. "I couldn't have done so well myself under such conditions," said the reporter.

The writer next wrote on the board the figures

$$\begin{array}{r} 7\ 5\ 9\ 2 \\ 5\ 1\ 3\ 8 \\ \hline \end{array}$$

and said to the horse, "King, subtract." The trainer then called to him to perform the process, using, so far as one could follow him, substantially such language as he did during the addition process. The horse in this experiment always pushed off the right number, but he also pushed off one or two other numbers in each instance. He would stop in the vicinity of the right number, while his trainer was talking to him, but apparently he could not discriminate between the correct one and those on either side of it. The trainer kept telling the audience that King knew perfectly well what was right, but he was "out of sorts to-day." So far as one could tell, the horse was utterly indifferent to his repeated verbal chastisements, even though, according to the trainer, he comprehended everything said to him and about him.

Next, the writer put on the board a problem in division, and one in multiplication, and the horse solved each problem in the way in which he did the first two; but in most of his attempts he pushed off more than one number, which the trainer uniformly ascribed to the cold weather, or to some similar cause, and not to lack of intelligence. His most remarkable arithmetical work, judging from the expressions of the audi-

ence, was his correct solution, in the same sense that his other solutions were correct, of the problem,—"If I must pay 35 cents for one dozen oranges, how much must I pay for 224 dozens?" King "solved" this "in his mind," which is more than the average high-school graduate can do. Also, he apparently carried the solutions of all the other problems "in his mind" after "studying" them once, which would be regarded as "some" feat for a mathematician even.

Stopping a moment for comments, it may be noted first that the trainer while commanding the horse saw the numbers on the rack, and that the horse passed *along* the rack, instead of walking up straight to a number. It was impossible to keep tab on all of the trainer's talk so as to determine whether he always used a given word or phrase when the horse was opposite a particular number; but some observers in the audience believed that this was true, and that the phrase he used was "Show the gentleman." It was thought by some members of the audience that the trainer always stamped his foot when the horse was to move back on the rack in order to find the right number. The writer, who remained at the blackboard while the horse was "studying" the figures, noted that he did not appear to concentrate upon them at all. The trainer would say to him as the numbers were being written, "Now, King, study these numbers, so that you can do your work quickly." The horse on at least two occasions nibbled at the writer's fingers while the numbers were being written. Once he looked out of the window; and from the focus of his eyes, which were specially observed, it appeared impossible for him to be attending to the numbers which had been written. If a child had been doing this work he would have shown in his bodily adjustments that he was concentrating upon the situation before him, but it was just the other way with King. The trainer would tell him to figure a problem all out before he went to the rack, so that he could do his work fast; and assuming that he did this, it indicated a higher degree of numerical imagery and retentiveness than the majority of human beings possess.

After the arithmetical tests, the writer introduced King to three of the observers situated in different parts of the room. Then five ribbons of different colors were put on the rack, after which the writer said to the horse,—"King, take the orange ribbon to Miss W." The trainer followed with, "King, do as the gentleman bids you. Find the orange color." The trainer was constantly talking to King, and stamping to make him obedient, and the horse soon picked out the orange ribbon and apparently went directly with it to Miss W., throwing it at her. The writer next said, "King, find the blue ribbon and take it to Mr. X." Again the trainer talked to the horse while he was performing the task, with the result that he found the blue ribbon, and took it to Mr. X. Miss W. threw her ribbon onto the floor, and the trainer said, "King,

pick up the orange ribbon and take it to Dr. O." The horse picked up the ribbon, turned around, and did exactly as he was commanded; and in this case, neither the writer nor the observers could detect any cue word or signal which was used to guide the horse. It should be said that all the observers were much impressed with the directness with which the horse appeared to go to the individual whose name was mentioned in any of these tests, though when King was being introduced to a person he did not seem to pay any attention to him. A human being would *look* at any one to whom he was being introduced, so that in the future he could recognize him through having focalized some of his characteristics; but King's eyes never once focused on the person to whom he was being presented. During the ceremonies of introduction, King might be sniffing at the writer's hand, or nibbling at his coat, which would cause the trainer to exclaim,—"King, why don't you behave yourself? I will have to whip you." But still when the test came King seemed to most of the observers to have recognized each individual to whom he was introduced, and to have remembered his name.

Next the writer asked King to spell the word "horse." The trainer took him in hand, talking to him and stamping; and the horse went along the rack and, as with the figures, pushed off in order the letters h-o-r-s-e, pushing off also letters next to the correct ones in each case. Several other words were given him, all of which he "spelled" under the guidance of his trainer. Lastly the writer printed on the blackboard the words, "Take my gloves, and give them to Miss W." The horse apparently searched around the body of the writer, but could not locate the gloves. The trainer gave the audience the impression that King was trying to find them; but while they could be seen extending out of the pocket, yet the horse did not take them. The effect created on the audience was that the horse was actually hunting for the gloves. It was noticed that as he was sniffing up and down the body, the trainer was repeating, "Do what the gentleman has asked you to do." It should be noted further that the writer stood directly before the horse, and it would be a simple matter for him to associate such a word as "gentleman" with taking something from his person. It is a frequent test for exhibitors with horses to have them take something, usually the hat from a man's head, and give it to some one in the audience.

These experiments having been concluded, the trainer and his assistants were asked to leave the building, and the horse was turned over to the writer. Before leaving, the trainer said, "The horse is very mischievous to-day, and you will have to look out for him." This had the desired effect, or at least it caused many of the observers to seek places of safety, which put them in a non-critical attitude toward the experiment. In this connection it should be mentioned that the trainer gave the writer before he took charge of King, and apparently in an incidental manner, a newspaper article which ran as follows:

> "King Pharaoh," an "educated horse" who made his initial bow at Wonderland Park yesterday, vindicated his honor at the close of one of the performances of the day. There was a "doubting Thomas" in the audience who thought the horse must have been given signals of some sort to perform the mathematical and other wonders which were revealed during the performance.
>
> The man of inquiring and suspicious nature was told by Dr. J. M. Boyd, the owner and trainer of the horse, that after the audience had left he could remain and see for himself in the absence of the horse's trainer. The "doubting Thomas" was left alone with "King Pharaoh." Shortly the man made his exit with much expedition, with the horse a close second. The animal, the man said, had obeyed several commands but seemed to become offended and "went" for him, as if knowing he was confronted by a doubter.

It seemed apparent that the object of this was to impress the writer with the desirability of his not being skeptical about King Pharaoh's abilities, or the horse might attack him and do him harm.

After the trainer and his assistants had left the hall, the writer repeated every one of the experiments which had been performed by King when his trainer was present. It may be stated in brief that he failed to perform a single test satisfactorily. When told to go to the blackboard, without any gesture or sign other than the mere words of the command, he did not respond. He could not react even to the word "blackboard." But when urged with the uplifted hand in the act of striking, and guided in the right direction, he would go and "study" the numbers. But when invited to go to the rack and perform the solution, he seemingly had no idea of what was said to him. But when urged and threatened, he would pass along the rack without knocking off any number. It was impossible to get him to remove a number by telling him simply to find the correct one. It was the same in regard to the spelling. In some cases when he was commanded in a threatening voice and manner to find numbers, he would paw, indicating that he seemed to think the command was to count. The only reaction that could be got from him was to stand before the blackboard, walk along the rack when urged and threatened with a stick, but without any disposition to solve problems, and paw when a command such as "Go and find Miss W." was continually repeated in an increasingly austere voice. It was evident that the horse had no imagery whatever for the words "Miss W.," and no notion of what was wanted of him.

The trainer, who after a considerable period had come to the building to find out the progress of events, and who stood on the sidelines while the writer was trying the horse out on some of his feats, finally could not endure it any longer, and came into the ring, saying to the audience, "Once in a while King will come across a man for whom he will do nothing; but he will readily do it for most people." This remark had the desired effect. Some persons in the audience were led to think that the writer was not in sympathetic accord with the horse, and

so could not induce him to perform his usual tasks. At once the writer called upon Professor Cooley, an expert on horses, who was in the audience, and who had seen the performance from the start, to take charge of the horse, which he did, with exactly the same result as the writer had. Next the principal of the high school in Miles City, who could not be accused of any skepticism regarding the horse's ability, or any want of sympathy for him, was asked to put King through his paces, but he could not get a single intelligent reaction from him. It ought to be added that the writer was simply neutral in his attitude toward the horse throughout the trainer's performances; he did not praise or censure; he simply took notes on each event, which impressed both the trainer and some of the observers as denoting a too critical and unsentimental relation.

It was to be expected that the trainer of King would explain his disappointing behavior as due to the paralyzing influence of strange personalities, and indisposition of some sort, for he had "never acted that way before." So another experiment was determined upon, and it was agreed that Dr. Boyd should handle the horse himself next time, and the writer would simply tell him what tests should be made. Now, it was mentioned above that in the language and arithmetic tests, the trainer as well as the audience saw the letters and figures, which made it impossible to eliminate the trainer's influence in guiding his horse, even though he might be unconscious of it. In order to try out this point it was decided, and it was thought without the trainer's knowledge, to prepare new blocks with letters and figures only on one side, and to arrange them on the rack so that the trainer could not see them while directing King, but so that the horse and the observers could see them. It was also decided to blindfold the trainer while the horse was being tested on his ability to discriminate colors, and to select special ones to give to persons to whom he had been introduced. Strangely enough, just before the tests were to be made the trainer declared that King had suddenly been taken sick, and could not be tested, though "nothing like it had ever happened to him before." To clear up the sitution, which looked very bad, Dr. Boyd promised to bring King to Madison, Wisconsin, for further experiments before January 15, 1912; but from that day to this (October 1, 1912) it has been impossible to get any response from him, though King is still amazing people with his "human intelligence."

Any one familiar with horses knows that they are capable of keen responses of a particular kind. They can very acutely distinguish tones of voice in respect to their denoting gentleness, or harshness, or weakness, or sternness in their possessors. Dogs have the same sort of keenness. Very young children, before they understand a single word as a symbol of meaning, can discriminate a number of shades in vocal qual-

ity. A horse can learn the significance of certain words which denote simple, definite reactions, as "gee," "haw," "get up," "whoa," and the like. He can be taught to respond in special cases to a considerable range of visual and auditory signs or cues, as may be observed in any circus. He can discriminate strangers from his caretakers, alike by smell and by sight, and also by the "feel" of the rein in driving him. The dominant emotion of the horse is fear, and he is keen in noting the characteristics of persons or places or objects which have been associated in his experience with pain or terror. He is extremely cautious, which keeps him ever on the alert, with the result that he will respond to simple stimuli in the form of "lessons" much more readily than the cow or the sheep, for instance. King is undoubtedly an average horse in this respect. As a result of repeated "lessons," he has associated a few visual and auditory signs with definite responses, and he has probably connected particular reactions with specific words, as "gentleman," or "show the gentleman" which is, of course, but one word to him, denoting a specific reaction, just as "whoa" does. Unquestionably much of his performance depends upon the peculiar vocal and bodily mannerisms of his trainer. When these are removed, King is at sea, hopelessly befogged when he is requested to do anything.

Those who exploit the intelligence of the horse, and other animals as well, usually try to show that they possess the traits of the human mind, in that they can understand sentences in ordinary speech, can read and spell and calculate numerically, can learn the names of people and discriminate their character, can interpret facial expression, and so on. Now, all these acts and processes demand a synthesis of particular experiences which it is safe to say the equine brain is incapable of under any kind or degree of education. If a horse could do these things, it would cease to be a horse. The reason a horse is a horse psychically is because it is limited to certain types of intellectual synthesis and affective reaction, all of which have been determined by its ancestral history. It would be just as sensible to say that a man could be educated to follow the trail of a fox from the scent of its track, as to say that a horse, or any other animal, can be trained to read or calculate sums or discern a skeptic in an audience. This is not reflecting in any way upon the intelligence of the horse; it is simply discriminating between the characteristic types of equine and of human intelligence. But if it were not financially profitable for some persons to possess horses with "human intelligence," we probably should never be called upon to wonder about them.

THE ADVANCEMENT OF PSYCHOLOGICAL MEDICINE

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TEACHING and research are the coordinate ways upon which any body of knowledge advances. Though we are apt to think first of the former, the latter is indeed the more basic, since before we can talk of teaching we must acquire something to teach; as, to a large extent, it is still the task of psychological medicine to do. It is neither a difficult nor an especially effective matter to urge in generalities the desirability of medical training in psychology in the hundred trite phrases that are current to every one; the abstractly favorable judgment is now of little meaning except as the basis of constructive ideas. We can best decide the place of psychology in medical education in examining what is the best that psychology has to give it. This question could indeed be dealt with more simply if there were greater unanimity of opinion as to what this best may be; for, as the recent addresses at Washington plainly showed, divergent opinions still reflect the different angles from which the subject is approached. The discourse of the medical man is one of problems, of the psychologist, one of methods; which under present conditions could scarcely be otherwise. The difficulty is that the methods of normal psychology and the problems of pathological psychology do not fit. One could well read this in and between the lines of Franz's remarks,[1] deprecating certain inadequacies in the methods of pathological psychology, as well as the aloofness from practical issues on the psychological side. The doubtful attitude of the psychiatrist towards the psychological *Problemstellung* is of long standing. "They ask for a psychology . . . applied toward a solution of their own problems, one which is aimed at practical ends. It has been assumed that psychology as it is being taught and investigated deals with matters of no concern, or of too abstract a nature for practise"; which assumption indeed has some measure of truth.[2] Psychologists may not be scientifically at fault for this failure of application, but the medical justice of demanding it can scarcely be gainsaid, and such expressions are fair warning that in our natural wish to extend the scope and influence of psychological science, we do not lose sight of the fact that if psychology is to be successfully taught to medical students, it must afford them something they can use. The test of concrete experience is one that psychology has never been seriously called upon

[1] *Journ. Am. Med. Assoc.*, March 30, 1912, 909–911.

[2] Cf. Hollingworth, *Psych. Bull.*, May 15, 1912, 204–206.

to face, in the sense that other natural sciences have been. I am fully mindful of Professor Titchener's[3] cogent *apologia* for the failure of the contemporary psychology to "hold its men," who tended either to leave it for more frankly speculative departments of thought, or sought the concreter fields of education, or physiology and therapeutics. But the fact seems to be that psychology has not been over-forward in seeking the test of concrete experience.

A somewhat definite program for the medical course in psychology has been discussed by Watson.[4] It seems, not unnaturally, determined more by the place of the methods in experimental psychology than by direct consideration of their applications to the study of psychopathological conditions. From this standpoint, one might in minor detail suggest some modification of Professor Watson's plan; thus in any work on sight, campimetry should probably occupy an equal place with color vision. The skin and kinesthetic sensations have a psychopathological importance quite equal to that of hearing. Watson's plan is for a systematic experimental course; I must confess that what seem the most fitting topics do not coordinate themselves so readily in my mind, and my own tendency would be to make such a course less one in experimental psychology than in psychological experiments. The content of the laboratory course may indeed change with the progress of the science, in accordance with the principle that properly governs it; but as we are not trying to make psychologists, but medical men, we must subordinate the desideratum of the academic system to a series of those experiments and methods most likely to be made use of in actual medical practise. It is evident that in the determination of the proper subject matter of such a course, there enters not only the available stock-in-trade, so to speak, of experimental psychology, but also the consideration of those particular clinical exigencies in which they are likely to be of service. Only such experiments and methods should form a part of such a course for which definite value in special situations can be indicated; and the understanding of the application is on a level of importance equal with that of the experiment itself. The application of experimental methods will, of course, be practically confined to the study of individual cases, and the procedure which should be followed in the laboratory is thus an intensive study of each experimental method with individual subjects; group experimentation or methods which involve it are out of place in such a course.[5] In an enumeration of the experimental methods which would seem, from the writer's particular experience, to best deserve place, would be included the study of the

[3] *Am. J. Psych.*, XXI., 1910, 406–407.

[4] *Journ. Am. Med. Assoc.*, March 30, 1912, 916–918.

[5] Cf. Kraepelin, "Ueber Ermüdungsmessungen," *Arch. f. d. Ges. Psychol.*, I., 1903, 28.

free association experiment, the technique of the "psychogalvanic" reflex, or some allied method, the properties of the work-curve and a few of the less equivocal methods for determining it, and the better developed forms of memory experimentation. Nor should I question the inclusion of the Binet-Simon tests, though without personal experience with them. It would lead too far afield to explain just why these particular experimental methods have been spoken of and not others, but suffice it to express every assurance that they are among the methods most helpful to the better understanding of those cases with which psychiatric clinics are replete. It is true that such division would form practically separate units in the course, and they could be taken up in any desirable order, save that, *e. g.*, certain phases of the association experiment and the "psychogalvanic" reflex are best considered together. Whether the content of a laboratory course were as above or something totally different, it must be governed essentially by its medical usefulness, and those features included which best justify themselves in this light. How much time can be given, and when, depends of course on administrative factors; all the time that Watson suggests could be profitably used, and it should be so ordered as to be convenient for those who take up the special work given in mental diseases.

Such, in principle, is the writer's conception of a laboratory course likely to be of most value to students of medicine, nor would it be claimed that its subject matter could be effectively dealt with under other than laboratory conditions. There yet remains that considerable body of psychological problems whose concern with medicine is not less immediate than those above, but whose relation to experimental, or indeed in any way objective, methods, is at present very indefinite. They are essentially problems of psychogenesis—the development of the various mental reactions and tendencies of which individual character and temperament are built up. It is readily discernible that a growing emphasis is laid in psychopathology upon the determining if not conditioning rôle of psychogenic factors in a variety of conditions, ranging from hysteria to the manic-depressive group; though the scientific development of methods, or their application to the study of normal mental reaction types, has been largely conspicuous in absence.

It is this phase of the situation that looms largest in Meyer's vision,[6] with especial regard to its problems. The point of view goes back to some basal concepts of "mental reaction"[7] and the remarks represented a none the less forceful, if indirect, criticism of the conventional *Fragestellung* in its relation to the problems on the pathological side. While at various times psychological writers have deprecated the tendencies inherent, from a scientific standpoint, in many doctrines associ-

[6] *Journ. Am. Med. Assoc.*, March 30, 1912, 911–914.

[7] Most simply outlined in the *Psychological Clinic*, June, 1908, 89–101.

ated with the name of psychoanalysis, it would be difficult to deny that the responsibility for psychoanalysis rests to some extent with the psychologists ourselves. The neurologist found himself confronted with certain problems psychological in their nature, with which the academic psychology had largely thought best not to concern itself. It is true that we have an "individual" psychology; one of the differences in simple reaction time, in color vision, or in memory for nonsense syllables, various elementary traits among which it has been difficult to establish relationships or other than superficial interpretation. From a medical standpoint it is better to give up this *Problemstellung* of individual differences in functions, for one, so to speak, of individual differences in individuals. The medical requirement is rather for a psychology that shall seek the correlation of objective methods for studying the personality with the mental reactions of that personality in the greater laboratory of mundane experience. The key-word to what medical psychology should be, and what academic psychology has not been, is, in fact, "*personality*." To our conventional chapter-headings of imagination, will, habit, experience and the like, let us mentally add the words *as they affect the personality,* if we wish to reach the standpoint of the greatest help in the medical relation. We shall study the mental evolution of the individual, rather than the genetic psychology of different mental faculties. Our psychology will be one of conduct, reactions, adjustments. As such we shall pay greater heed to feeling as a disturber of these adjustments. We shall start from the standpoint of the "mind as an adaptive mechanism";[8] the personality as a sum of various tendencies in mental adaption or reaction-type. We shall study the various mental means through which different personalities react upon, or adjust themselves to, the vital situations they meet. We shall learn how some personalities react in ways that involve mental good, others in ways that involve mental harm, and we shall inquire into the modifiability of these reaction types, with the view to their possible amelioration.

Though having a somewhat different outlook upon the matter, and expressing it in different terms, it appears that the things which Prince[9] finds to criticize in the pathological relations of the academic psychology are essentially the same.

> The problems with which normal psychology has chosen to deal are exceedingly interesting from the point of view of the higher culture, but they scarcely touch the vital questions which the disturbed, distressed human organism presents to the physician. . . .If normal psychology is to become an applied science and in particular to become of help to medicine, . . . it must occupy itself more than it has done with problems of dynamics, of mechanism, of function.

[8] Cf. a lucid but uneven article by White, "The Theory of the 'Complex,'" *Interstate Med. Journ.*, XVI., 1909, No. 14. Also in "Mental Mechanisms," Ch. 4, pp. 48–70.

[9] *Journ. Am. Med. Assoc.*, March 30, 1912, 918–921.

He goes further, however, in formulating a definite scheme of instruction. This is governed in certain details by its author's special psychology; some rearrangement of headings, if not also some alterations of terminology, might well prove desirable. Yet it is quite evident that in a number of the titles we have at least an enumeration, in greater detail, of the phases which a course along the lines above indicated would take up.

When Dr. Prince was reading this summary in Washington, I turned to some one sitting next to me and rather lightly remarked that this was all very well, but Prince was the only man who could give such a course, my neighbor promptly assuring me that I was altogether mistaken, that he knew many persons who could give such a course. It was not meant, of course, that there was no one who could talk about these subjects for the number of hours the course would specify. But we can not consistently reproach psychology for our lack of knowledge in these matters, and at the same time propose their immediate fitness as a teaching subject. As a matter of fact we have very little systematic information about the majority of the topics presented in Prince's summary. It is most likely to increase if the student be brought to observe and study in his cases in these terms, but this side of the course could to-day no more than reflect the subjective reactions of certain original and more or less critical intellects upon the most adequate clinical experience.

The interest and import of these questions most thoughtful persons will admit, though any psychological critic would probably be quick to ask how such matters are to be in any part submitted to objective, not to say experimental, inquiry. Not with the color-wheel probably, or through the tonvariator, or the sound-hammer. Could the question now be satisfactorily answered, the proper psychology for medical schools would not be long under discussion. We are not in a position to say, however, that no progress towards a solution is possible. Our experimental inquiries have not been directed along lines that would develop such methods. We must also know with greater exactitude the questions our experimental methods are to be put to answer, and shall need to experiment with our experiments a good deal. There is to-day only one experimental method whose direct value in the dynamic psychology seems comparatively assured; this is the ordinary "free" association experiment, especially evaluated.[10] There are also some possible adaptations of the method of "measurement by relative position"[11] as well

[10] Cf. the "Diagnostische Assoziations studien" of Jung; Kent and Rosanoff, "A Study of Association in Insanity," *Am. Jr. Ins.*, LXVII., 1910, 37–96, 317–390.

[11] Cf. the early work of Sumner and the more recent studies of Hollingworth and of Strong; also, in pathological reference, G. G. Fernald, *Am. Jr. Ins.*, LXVIII., 1912, 545–547.

as other quite specialized tests, that hold out promises of value in these directions.

It will be appreciated that a dynamic psychology has no exclusive relation to the pathological, but rather seeks the recasting of psychological problems into a form more applicable to the uses not only of pathological psychology, but of normal psychology and society in general. It is in no way specificially referred to pathological material. Because psychiatry has to deal, on the mental side, with personality, it desires a psychology of personality. The study of normal personality, as such, has its obvious and necessary relation to the pathological. The university is in quite as favorable position to make essential contribution to a psychology of personality as is the hospital or clinic. Research in this direction encounters certain difficulties that are avoided in the customary lines of psychological investigation, but this is so by very virtue of its having personal applicability, its bearing upon more intimate and vital issues.

To adequately cover the teaching field of psychological medicine one should therefore, on the one hand, be conversant with and able to judge of the methods of experimental psychology in reference to their application to the analysis and interpretation of symptoms; and, on the other hand, able to recognize and elucidate the more general questions now stated dynamically. First-hand acquaintance with psychiatric conditions and problems is everywhere implicit, which involves the close and continual association with clinical material that is also necessary for research. Here then the problem of research merges with the problem of teaching, and we shall consider some phases of the subject also from this standpoint. It is proposed to discuss in this connection not the further special topics of investigation,[12] but the practical conditions under which such research takes place, and the most effective means of furthering it.

The essential clinical material of psychopathology is derived from various sources, approachable from different angles. According to social stratum, the neuroses and various border-line and neurological conditions are most seen either in the private practise of the specialist, or in the appropriate departments of the general hospitals; the psychoses, as the term is generally understood, in the state or private hospitals devoted to their care and treatment. Special institutions, as a rule, care for the graver congenitally defective (feeble-minded) while in some instances it has been found advisable to provide special institutions for the management of such conditions as epilepsy and alcoholism. Much the greatest amount of material, and in its most accessible form, exists therefore in the institutions; though it does not so greatly

[12] Some of which the writer has dealt with elsewhere; cf. "The Experimental Method in Psychopathology," *N. Y. State Hospitals Bulletin*, December, 1910.

surpass in psychological interest the smaller group of neurotic conditions that do not regularly come under institutional care.

It is not now easy to say how this latter group of cases will to any extent be brought under the observation of the psychologist. Except in isolated instances, the material of private practise may be systematically observed only by the physician who treats it. For our psychological understanding of these cases, we shall presumably remain dependent upon such studies as the specially interested physician is able to make in the course of his practise. These researches should improve in number, if not also in quality, as medical students acquire more knowledge of psychopathological problems, and of the means by which to approach them. The case is more favorable with that part of this material than is seen in general hospitals, or in small private institutions, but the obvious economic difficulty of providing for the systematic psychological study of this material is one which it has not yet been attempted to meet. If these conditions are thus less accessible as a group, it is partly compensated for by their greater accessibility as individuals, owing to the generally better preservation of the intellect and cooperative faculties, so far as these enter. In the comparative study of the neuroses and psychoses, these factors to some extent balance each other.

The most practical means to further the accessibility of psychopathological material for psychological research, has been through the establishment of research positions in the institutions whose facilities are adequate to them. The past decade has witnessed the inception of a considerable amount of this work, under various state and private auspices. The conspicuous success of Franz at Washington and of Goddard at Vineland may be mentioned. These positions have been regularly filled by persons of the university training in psychology, who are expected to devote their time to original investigation. Whatever the special character of the material investigated, the main responsibility for psychopathological investigation will rest—and perhaps it may be added that it ought to rest—with the men in these positions, relieved of the perpetual penalty of therapeutic promise. As the success of these positions depends upon the men whom they will draw, and this in turn upon the opportunities they offer, it may be well to briefly analyze from both standpoints the external conditions under which this work is done.

Institutions that make scientific appointments are presumably ready to devote themselves in some measure to work of a purely research character, the immediate practical realization of whose benefits is likely to be a matter of more than ordinary good fortune. The creation of such positions therefore implies in the administration a fair degree of sympathy with scientific motives. Institutions inadequate to this de-

mand are scarcely suited for such positions, nor are good men for the work likely to be drawn to them. The salaries vary somewhat from place to place, and according as the incumbent lives within the institution or out of it; but a fair average compensation for work of this nature has been $1,200 a year plus maintenance. The teaching positions which psychologists ordinarily enter do not, of course, provide training of any particular technical value for these research activities; in some cases they might even lessen fitness for research. As Wallin[13] put it, the only adequate training in this respect is an apprenticeship with one of the experts in the field, which is very rare at present. On the other hand, much might be said for the value of direct experience in allied fields, and their additional contacts with the broader problems of social psychology. In Titchener's ever-apt phraseology "the best work will always be done by the best men," who, with a mature outlook upon the psychological situation and its problems, enter the pathological field because of exceptional interest, or are selected at the outset of their careers through evidence of fitness and promise in these special questions of research. With the above reservation, the candidate is the fitter for the position the less the time since his Ph.D., and the positions should be made attractive to those at the outset of the psychological career.

If qualified men are to be drawn to these positions, they must be given a standing in keeping with the class of work expected of them. It should be commensurate with that accorded to the pathologist, who forms an integral part of the institution staff. Discrimination will simply exclude the more competent men. It is doubtful if the scale of salaries needs to be altered greatly. The additional cost of carrying on such work would include not less than $150 for annual library expenses, the remainder being dependent on the sort of work done, and the special equipment it requires. Many fruitful lines of inquiry require but little apparatus beyond stationery; some important problems, *e. g.*, those concerned with the expressive movements, require elaborate and somewhat costly installations. Administrative direction of the precise subjects of research is not usually advisable, however, since it can seldom be guided by an adequate knowledge of the limitations of methods. In no case should the attempt be made to equip a general laboratory, but only to provide such equipment as is necessary for the investigations in hand. At some time in most investigations a certain amount of clerical assistance is an all but absolute requirement, and no holder of such a position should be expected to do his work properly without it. The greatest possible latitude should exist in regard to questions of printing; if an investigator is not to be trusted to publish when, where and what he thinks best, something is wrong with him or his position.

[13] *Journ. Educ. Psychol.*, April, 1911, 208.

As the worker in an institution laboratory does not have the same opportunity to place his work before *Fachgenossen* as is the case with his university colleagues, the institution may well accord some facility in the distribution of offprints.

From the standpoint of the young Ph.D., these research positions are economically quite superior to anything to be expected of the earlier years of a teaching career. As maintenance is provided, a very large part of the salary can, if desired, be saved; the conditions of living vary with the character of the institution, but may bring the actual value of a $1,200 position well towards $2,000. Vacations are short, compared with academic ones, but this may be quite compensated for by the absence of routine obligations and various other agreeable features of institution surroundings. The tremendous advantage, to him who is able to use it, lies in the freedom for original research; the possible disadvantages are the lack of library facilities, and the intellectual danger of isolation from colleagues. Absolved from routine activity, deprived of the immediate competitive and critical presence of others in the same field of work, the lack of energy and devotion means mental dry rot. However, being not only free, but expected to devote one's entire time to original research, one can obviously be more productive than his equally capable fellow-worker whose time is swamped by the routine activities of teaching; and, so far as personal advancement is based on the character of work done, the advantage seems to lie distinctly with the research position as against the teaching one. Still neither standing nor salary in these positions equals the professorial grade in the important universities, which is, practically speaking, the material end to which those following the career of psychologist now look forward; and once having abandoned the teaching side of the profession one is not likely to reenter it at a higher level, save upon evidence of altogether distinguished merit, probably more than would be necessary should the candidate follow the routine of academic promotion. For the greatest abilities these positions should then offer the greatest rewards; to mediocrity they spell destruction.

The cause of research in psychological medicine will prosper the better, the longer its special class of investigators can be held to their work. At present, the best men may not remain in it permanently, but be taken away at a time when their growing experience makes them increasingly valuable in it. It can not, of course, be questioned that this same experience, with the facilities of the position, places one in a peculiarly advantageous situation as regards teaching the subject, which it might be advisable also to do, in so far as it were possible without hampering research. University association with clinical research further offsets the possible difficulties of inadequate libraries and isolation from colleagues. An additional advantage of university associa-

tion is that advanced students, academic or medical, may be brought into direct contact with research problems in psychopathology and means thus provided for the carrying on of much additional investigation. Under the present circumstances the clinical psychologist might often occupy his time very effectively with the combination of research and the training of others in its methods and problems; while from a practical standpoint it also tends to retain him longer in the work to do so.

The optimum of teaching in medical psychology involves, therefore, a unification of instruction and research. It deals, on the one hand, with the clinically useful procedures of experiment; on the other, with the broader problems of personality and psychogenesis. Its contemporary sources are, on the one hand, the university laboratory, on the other, hospital clinic, and it is best served by the experience of both. Throughout, it has been apparent that the subject matter of psychological medicine is one of particular appeal to students specializing in mental diseases, and should for the present be elective. It would be rather unwise to now seek the required study of psychology in medical schools, as psychology is not yet in a position to make sufficiently definite contributions of general value. Only through the encouragement of research, and its direction through proper teaching, are its great and obvious deficiencies to be supplied, and the endeavor has been to indicate how psychology and medicine can best meet upon grounds of mutual helpfulness towards this end.

IMMENSE SALT CONCRETIONS

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Crystalline salt masses may be a mile in diameter! Where are they? How were they formed? Who said so? Interrogations like these are sure to be forthcoming from layman, chemist and geologist alike whenever such startling assertions are made.

Salt is a common substance. Its occurrence in the waters of the ocean, as well as those of land-locked, mouthless seas is a matter of common knowledge. Interesting articles too, have been written regarding the immense layers of rock salt within the earth's crust. They have told of the hundreds of years required in excavating the great chambers and galleries in the Austro-Hungarian mines at Hallstadt, Ischl and Weiliczka. Such mines have been the *chose-à-voir* for travelers in this monarchy for the past two or three centuries. The Stassfurt mines have become known throughout the world for the richness of their potassium deposits. The Salt Mountain of Cordova, Spain, and the Salt Cliff at Bahadur Khel, in the Trand Indus region of India, are among the notable rock-salt occurrences.

All these salt accumulations have been explained (and perhaps properly) by supposing that they represent the residue of evaporated saline waters, waters that occurred in cut-off bays or sounds, receiving but occasionally supplies from the neighboring ocean, scarcely equaling the vapors lost by evaporation.

Of late an entirely new method of accumulation or growth of rock salt masses has been discovered. Here the salt no longer occurs in thin but wide-extended sheets, layers or strata, but in huge lumps, concretions we may say, with vertical and horizontal diameters approximately equal. These are the masses we wish here to bring to the attention of the reader. We do not have to go to Spain or India to see these marvels. They are, so to speak, right at home. They occur encysted in the sands and clays of the later geological formations along our gulf coast, from east Texas to south Alabama inclusive. Not all are immediately along the gulf border, to be sure, but the majority are but a few score miles from this line. All have doubtless a general conception of the low, grassy marsh-lands of southern Louisiana with its intricate system of tidal bayous beset here and there with dark green live oaks giving the appearance of old-time great apple trees in a great meadow, when viewed from a distant vantage ground. Doming up here and there in

these monotonous marshlands are great swells of terra-firma, one hundred or more feet in height and a mile or more in diameter. They are seen from a great distance, and strike one at once as being something out of the ordinary, surely formed by no common method of uplift, less yet by circumdenudation. Of these coastal mounds the so-called "Five Islands," lying to the east of Vermilion and Atchafalaya bays are splendid examples. Belle Isle is just to the west of the Atchafalaya River, between Morgan City and the Gulf, Côte Blanche, Grande Côte, Petite Anse and Côte Carline follow to the northwestward in the order named. The first, or Belle Isle, is famous as the fabled residence of Lafitte, the great Gulf pirate, Grande Côte and Petite Anse for their salt mines and Côte Carline for the southern home of Joe Jefferson, the actor. The drill has demonstrated the fact that these rounding hills are the surface indices of salt masses below. Down one, two or three thousand feet drills have penetrated with but little variation of matter and structure, making, as already observed, the salt masses perhaps as deep or deeper (thicker) than they are in horizontal diameter. Just off the mound one may drill two thousand feet and encounter nothing but soft clays and sand of Quaternary or "Recent" age. Below are similar materials belonging to the Miocene Tertiary; there is no salt, sometimes not even salt water. Such strangely local salt lumps naturally have troubled the philosophical geologist not a little. Some have said they must have been formed in the crater of some dying volcano, sea-waters having oozed in and evaporating deposited salt for years and years in a streaming caldron. But alas for this explanation, these salt masses are not simply the residue of evaporated sea water, they are 99 per cent. chloride of sodium and without the admixture of crater débris. They are pure and solid. Again, though careful magnetic surveys have been made about them, they fail to show any of those erratic local variations sure to occur in volcanic regions. Finally there is proof positive they were never deposited in a hole or depression, but on the contrary have even *moved upward bodily through hundreds of feet of surrounding deposits!* This seems at first absolutely impossible and as certainly absurd. Nevertheless, we can demonstrate the point beyond doubt. Note that we have said that certain of these salt lumps occur some distance from the Gulf coast, up country, so to speak, where the terranes are of Tertiary and Cretaceous age and are more or less consolidated. For example, in north central Louisiana salt comes near the surface of the soil in circular areas. Surrounding these areas are rings of highly tilted Cretaceous deposits, still outside are the lower Tertiaries, 1,000 or 1,200 feet thick. Clearly then these salt punches, so to speak, have pushed themselves from amongst Cretaceous rocks right through the Lower Tertiaries, bending these strata up on all sides of the mass, to a height of 1,000 or 1,200 feet. The case then seems clear that the salt

masses have come from below and have moved upwards. This is as clearly demonstrated as the fact that the battleship *Maine* was wrecked from a force without "because the plates were bent inwards." Were the Tertiary and Quaternary beds removed from the flanks of these salt masses we should see a cylinder or perhaps more accurately a truncated cone of salt standing upon mid-Cretaceous rocks towering upwards half a mile or perhaps a mile, though the upper end of the cone might not be over $\frac{1}{4}$ mile across. Some one will say that is certainly similar to the church-spire spur that was lifted out of the crater of Mt. Pelée after its recent destructive eruption. Others will be reminded of Bogoslof Island in Alaskan waters. But here again, in endeavoring to explain the phenomenon there is no need of invoking vulcanicity. For the past ten years we have had exceptional chances to study all these interesting salt masses and are prepared to confidently affirm that the origin of both salt masses and their movements has nothing to do with volcanic action.

The true explanation of the origin, growth and movement of these salt masses seems simple when once we have a clear understanding of certain structural features of the lower Mississippi region. Observe on any geological map that Quaternary and older rocks back to the medieval or Cretaceous beds all slope Gulf-wards at a much greater angle than the surface of the ground makes with the horizontal. In other words, if water should enter a pervious Cretaceous or older bed in Arkansas and follow the same to the latitude of the Gulf border it would find itself several thousand feet below the Gulf level. Such waters would naturally become very warm as compared with water at or near the surface. They would take soluble substances in solution. If a break or point of weakness occurred in the superincumbent beds such hot waters would ascend after the manner of water in an artesian well. If the waters were saturated with salt at a high temperature they would be obliged to part with some of their saline burden as they approached the upper, cooler strata. The amount of salt held in solution by water at various temperatures, it is true, increases not greatly with increased heat; nevertheless, it is appreciable, and in the end the giving up of salt by lowering temperature would produce notable results. Again, though salt masses might tend to accumulate as just outlined at a certain place in the crust of the earth, would not pressure prevent such a growth, and even if growth takes place what would tend to push the salt up bodily say 1,000 feet or more? Here again we need none of Vulcan's aid, for we all know that when once crystallization commences each little crystal will have its growth in spite of almost any resistance. Witness the growth of ice crystals in our water pipes in zero weather. In other words, the force exerted by growing crystals is known to be at least of the same order of magnitude as the crushing

strength of the grown crystal. Therefore we are sure growing crystals of salt can lift a column of Gulf coast deposits at least 3,500 feet thick. If brine is supplied to a salt mass from below, crystallization will take place mainly on the bottom of the mass. Therefore the mass will grow from bottom up. The top will be thrust through the superincumbent beds, bending and tilting them up at high angles. Some growth would doubtless take place on the sides of the mass till it attained considerable dimensions; afterwards it would be confined to the base, for the column of rock salt would be a better conductor of heat than the surrounding clays and sands, hence the marked change of heat, hence the salt deposition would take place at the base of the salt column. The mass would therefore be of comparatively small diameter, though its depth might be great.

We see from the above considerations how salt masses might be formed and how they would by receiving their growth increments from the bottom seem to move upwards and pierce the superficial layers of the earth's crust and there be truncated by atmospheric agencies if they actually reached the surface, or how they might produce great weales on the surface in case they did not quite pierce through. Now we wish to give a few facts indicating that the process outlined above is truly that by which these salt masses were formed and pushed up. Referring again to Gulf-coast structural features, noting the location of all the salt masses known to date, we have little difficulty in satisfying ourselves that such masses are located in a rectilinear manner, row after row as we approach the Gulf border. These lines are parallel in a general way to fault lines farther up country in Arkansas and Texas. A movement along a fault line, similar to these, most readers will remember caused considerable trouble in the region of San Francisco but a few years ago. Where such lines cross (for in Louisiana there are two sets) points of weakness occur permitting the upflow of artesian waters. In several of the "mounds" these waters are saline and "hot."

Finally the source of the salt itself has been a subject of much speculation. However, it is a matter of no serious concern for us here. We know that artesian conditions occur in the general region we are discussing, we know that there are breaks or fault lines and points of weakness through which artesian flows may take place, we know that deep artesian waters are always regarded as "hot." We know that cooling saturated solutions of salt in water must be continually giving up salt; and as this crystallizes it forces aside and upwards superficial rock strata even to depths of several thousand feet. Not only do we know it has strength to do this, but, best of all, there in the Gulf region are the salt masses and there are the bent-up and folded-back rocks. Still we may be permitted perhaps to speculate re-

garding the source of the brines that have fed these growing crystalline masses. It is well understood that the thick coal-bearing rocks of west central Arkansas derived their material from the south. The Carboniferous continent extended Gulf-wards doubtless as far as the southern limits of Louisiana and perhaps considerably beyond. These old lands were eroded and swept northward into the Carboniferous seas of west Arkansas already referred to. In Permian or slightly later times this continental area was base-leveled, standing on a par with west Kansas and north Texas, receiving deposits of salt and gypsum in shallow sun-baked seas. After considerable accumulation of these saline materials the Gulf region was depressed at the south and covered by later and later deposits and the Gulf invaded the Mississippi valley to Cairo, Illinois. This was in late medieval geological times (late Cretaceous). Since then the central part of the continent has gradually raised, the Gulf border has sunk so that, through the Tertiaries and recent ages, the formations have been tilted more and more to the south till the salt-bearing Permian beds are doubtless 5,000 to 8,000 feet beneath these younger deposits. Hence in all probability the source of the artesian flow of brines that produce the salt masses under discussion.

COLLEGE OR UNIVERSITY?

By Dr. STEWART PATON

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WHAT is the difference between the college and the university? There is no blinking the fact that many of the students, most of the alumni, as well as a large proportion of the members of the faculties and administrative boards, including presidents, have very nebulous views in regard to the fundamental distinction that exists between these two classes of institutions. The successful administration of a college or university depends upon the recognition of the existence of a vital principle which distinguishes the functions of one from those of the other. Many colleges during the last thirty years have assumed the title of "university," having first given a promissory note to the public expressing their intention some day to make good their claim to the title. Thinking people have already begun to express doubts as to the satisfactory fulfilment in many cases of such a promise made before the conditions and responsibilities of the trust had been fully understood by either faculties or trustees.

The time has now come for a clear understanding of the nature of the difference which distinguishes the university from the college. The evils of the *laissez-faire* policy of administration which to-day prevails in the councils of our universities have at last aroused more than one faculty and not a few trustees to a realization of the fact that while a ship at sea without chart or compass may, if the fates are propitious, be brought safely into port, the mere accomplishment of such a difficult task does not increase our sense of confidence in those responsible for providing for the safety of the voyagers. A trustee of one of our eastern universities has recently affirmed that the greatest need of these institutions is not money, but the services of men who have just and definite ideas of the essential characteristics of a university. If our higher institutions of learning are ever to keep pace with the intellectual progress of the nation (the question of actual leadership can not yet be considered), there is immediate need of a statement emphasizing the distinction existing between university and college, in order that such an institution may develop a healthy independent existence.

What is a university? There are two ways of attempting to answer this question. First there is the method usually employed of approaching the subject by indicating the lines of historical development; or we may try, and this is the object for which this paper was written, to define this institution in terms which will indicate the relations it should present to the development of human thought and

activity. So many institutions have assumed the name without justification by deeds that it is necessary to lead up to our definition by a preface of negation. The university is not, as some people believe it to be, an overgrown college with an increased number of students, a larger faculty, and greater material resources. Neither is the principle upon which it is administered one that is based upon an expression of merely local or parochial interests. Chauvinism and insularity do not thrive in the true university atmosphere. On this account, it is impossible to conceive of any university as an institution which is solely dependent upon the support of its own alumni.

In order to understand the positive attributes distinctively characteristic of a university, we must have some clear conception of what constitutes an education; inasmuch as the institution under consideration represents the acme of the entire educational system.

Education, according to the original usage of the word, is a *leading* out process, marked first by an attempt to measure the individual's capacity and then to direct his energies along lines where growth is possible. From this it is obvious that the chief aim of education is the cultivation of good mental habits and not the imparting of information. Modern educational reforms have for their object instruction in methods of work, the information incidentally supplied being of secondary importance. The older system put the chief emphasis upon the imparting of information. First one set of correctives or tonics and then another was administered to students, and if they survived the treatment they were classed with those "who had received an education." Fortunately, there are signs that the age of this form of drug-giving is rapidly passing away. A few pedagogues still have faith in cultural specifics and liberalizing studies, with virtues as well advertised and as highly extolled as any of the life-giving tonics and nostrums of the quacks, but the general public is beginning to appreciate that the original use of the word education, or intelligent effort to e-duct, not a forcible attempt to ad-duct, expresses the modern trend of our educational system. Recently the suggestion has been made that mental training is the only remedy for most of the evils connected with our present system of education.

How often the cart is put in front of the horse! How often cause is mistaken for effect! People possessing special mental qualities have predilections for certain subjects and these choices are the expression of a complex individuality largely made up of factors acquired, not by training, but by heredity. The doctrinaire often attempts to reverse the natural order and attributes the characteristics of the personality to the subjects studied. If the humanizing and cultural potency of an education depends upon the proper selection of subjects of study, what a poor showing is made by the human race after centuries of expectant treatment! How long will the old superstition that all

mental disorders, as well as all bodily ailments, can be cured by administering the proper combination of drugs continue to delude a credulous public?

Modern education starts from quite a different standpoint, first taking into account the biological or inherited trends of the individual, and then trying to estimate his latent capacity or brain-power in the expectation of giving the assistance needed to help the student in the task of self-government and self-improvement. We talk so glibly about "hereditary influences," "individual capacity," "individualism as opposed to collectivism," that, if we had a keen sense of humor the ridiculousness of a system of tutelage which attempts to treat students *en masse,* without any reference to their inherited traits and natural capacities, would strike us as farcical. This method has been described as "education by cram and emetic." In the model school or college the different subjects should not be taught as ends in themselves, but in order to train the student how to observe intelligently, concentrate his attention, repress unhealthy instincts and cultivate those qualities making for a broader, saner life. From kindergarten to the day of graduation from the university the mental training of students is dominated to so great an extent by the servile preparation for examinations that a special degree of B.E. (bachelor of examination) might be conferred on all applicants who require written evidence of having satisfactorily "passed" in order to be assured of their right to be classed as "educated persons."

An education should, as Goethe expressed it, make it possible for the individual to live his life to the fullest. Only after the idea has been clearly set forth that education and mental training should be synonymous terms are we ready to comprehend the relationship of the college to the university. Having grasped this principle, we are then in a position to realize that in the school and college every effort should be directed to the formation of good mental habits, while in the university the student should be given, under general direction, an opportunity to practise these habits, and, in addition, to develop to the fullest extent possible the spirit of intelligent curiosity.

Without the presence of universities, whose chief aim should be to cultivate the spirit of investigation and of open rebellion against conventional teaching-authority, the intellectual vigor of the entire nation is seriously impaired. Political freedom can never atone for the loss of intellectual liberty which should be faithfully guarded by the university. In a democracy there is constant danger of forgetting that the loftiest ideals of freedom are not those associated with the political life of the nation, but are indissolubly connected with the search for the truth that alone makes its possessor free. How strange that in a nation which boasts of the freedom of its political institutions so little is done by our universities to encourage and protect the agencies which

are the basis of both intellectual and individual liberty, from the paralyzing influences that follow an attempt to meet the conventional social requirements in education. Intellectual liberty often thrives best in states where political freedom is restricted.

The collegiate university is so much occupied in distributing ready-made educational suits cut upon a single pattern to applicants for academic honors, that individualism is almost completely hidden by a garb which may conceal both the iniquities of mediocrity and the virtues of genius.

The American college graduate is so accustomed to the evils of a system in which he is pulled and pushed about by "trainers" that he is constantly in danger of losing his personal identity. His patience is often exhausted by listening to sermons on the advantages of scholarship, while he prays in vain for the opportunity to learn by observing living examples. Many of the crudities in our intellectual life as a nation are directly attributable to the failure to appreciate the importance of university ideals to the community and the nation. This oversight also emphasizes our reluctance to recognize that the spirit of enquiry is a normal instinct which if repressed is followed by serious consequences such as the loss of placticity, of intellectual vigor and of the highest forms of intelligent and sympathetic interest in one's own profession. The vision of those who are fortunate enough to possess the spirit of investigation, one of the surest signs of mental health and vigor, is towards the future, while the fate of individuals and institutions which turn to look back is the same as that of Lot's wife. "Denn wer nicht vorwärts kommt der geht zürück; So war es immer so bleibt es." Unless the spirit of enquiry is developed deep and abiding intellectual interests are impossible. In its absence we become mere gatherers-in of knowledge with but a slightly higher degree of intelligence than that possessed by collectors, but lacking genuine interest in progress. The spirit of discovery is generally accompanied by a childlike freedom from bias. Without the inspiration that comes from prosecuting research, our gaze is directed down into the valleys and not upwards to the peaks whither our aspirations lead us. The failure of our universities to encourage more extensively than has yet been attempted enquiries in the field of knowledge is largely responsible for our diffuse and shallow interests. We are prone to estimate the mental qualities of a student by counting the number of subjects he has studied without attempting an analysis of his mental traits. Any institution which publicly assumes the right to be the bestower of a liberal education should be prepared to forfeit its claim to the title of university, as this should be a function of the school and not of the university. The essence of a liberal education is to be sought for in the quality of mind of the individual and not in the character of the information he possesses. The futility of any institution solemnly prom-

ising to be the dispenser of these special mental traits during the latter years of the educational curriculum is quite obvious to those who know that mental habits are, to a large extent, definitely and permanently formed much earlier than this period. If the qualities commonly designated as balance, interest and sympathy, the dominant characteristics of those who actually possess a liberal education have not budded in the school period, they can not be successfully grafted during the university years. The formation of mental habits belongs to the school and not to the university period. To-day the university unfortunately limits its sphere of usefulness in our intellectual life to frittering away energies and resources in attempting to reeducate those who have failed to develop intellectual interests during the school years. At the age of seventeen or eighteen, when the average student enters the university, his mental habits are already formed to such a degree that the catalogued promises made to him of the efficacy of liberalizing studies smacks more of the east wind of authority than of common sense. If those who defend the present conditions of affairs as a necessary form of compromise are correct, then we may well be pessimistic of our future intellectual development, inasmuch as the university is revealed to us as a nurse for the sick rather than as a counselor and aid to the strong. The dominance of that kind of mediocrity which imperils the life of democracy is very plainly indicated in the present organization of our universities that make ample provision for the day-nursery treatment of those who are devoid of intellectual interests and ambitions, and take little cognizance of the great numbers of students possessed of mental health, vigor and praiseworthy ambitions.

Many parents and teachers have the unfortunate habit of assuming a semi-apologetic attitude when referring to courses of studies, as if they were tasks to be undertaken merely in order to satisfy the conventional demands of society, while all manly virtues are commonly referred to as if they could only be exercised by training the biceps and were quite independent of brain development.

At school attention should be directed to the value of constant continuous effort, emphasizing the fact that a desire to work with one's brain is just as much a sign of health as the wish to excel in physical exercises. The importance of mental habits and the formation of thought processes should be emphasized not only as a means of attaining success in practical issues, but as the essential factors in the preservation of mental balance.

The silly conventional values commonly attached to an education should be replaced by substituting those intellectual interests in work that add so materially to the pleasure of living. The success of an education and the intelligent interest of an individual in his occupations may often be directly measured by estimating the degree of pleasure taken in "talking shop." The devitalizing influences of our

present system of educational ideals is seen in the urgent desire of many college graduates to lead a double sort of existence, one half of the day with, and the other without, their professional interests. The attitude of so many college graduates to their profession is of such a nature that "hobbies" and "outside interests" are essential for the restoration of the mental balance which has been destroyed by the daily occupation. This "double life" necessitating a daily shift in ideals and ideas may become a prolific source of nervous disorders, varying in degree from boredom, even at the mention of intellectual topics, to pronounced mental derangements. The failure of our present collegiate-university to show that the real pleasure of life depends upon the association and not upon the divorce of intellectual interests from the daily occupation of the individual is one of the most serious defects in a system that sets a man adrift in his profession without any intelligent interest in it. The American student is so thoroughly imbued with the idea that "to be educated" is a condition or state of mind induced by teachers that he seldom realizes any of the pleasures associated with learning; and so in later years the practise of his profession becomes for him merely a method of making a living instead of being at the same time a source of enjoyment.

By exhortation, backed up by a vigorous policing, the American collegiate university has endeavored to drive students to the choice of high ideals, which are emphasized merely in order to satisfy conventional requirements. This is one of the most serious defects in our entire educational system, as it frequently becomes necessary in after life for the individual at a critical period to readjust fundamental mental mechanisms in order to meet the real issues of life. On the other hand, the cultivation of the spirit of intelligent and candid scepticism has been sadly neglected in our American universities. Students are taught to think only in accordance with the "cast iron rules" given them as guides to thought and conduct, while the more important lessons of searching diligently for the truth, and of being continually on the guard lest the rising mists of authority completely blind their vision, are seldom emphasized. The ideals of the alma mater more often suggest submission to a corporal than to the admonitions of a parent. In many of our universities to-day the doubts of the weak are crushed out of existence, while the resistance of the strong to a system of passive intellectual oppression breeds a spirit of rebellion. High ideals can not be maintained in an atmosphere where the value of intellectual honesty is not appreciated, or where the advice is not infrequently given, "Do not express your doubts in public."

Pater's affirmation, "What we have to do is to be forever curiously testing new opinions and courting new impressions, never acquiescing in a facile orthodoxy of Compte, or of Hegel, or of our own," expresses a well-known law of physiology seldom referred to in our universities.

The spirit of the real university should reflect the characteristics of youth in its love of testing new opinions and courting new impressions. Without the presence of a large body of investigators an institution ceases to live or, if vitality is prolonged, it is merely of the vegetative type. The spirit of investigation leads men to conquer difficulties which would terrify them if they were driven into the breach solely by the voices of authority. The spirit of investigation is as important to the artist, the business man and the writer as it is to the scientist in his laboratory. The American university has not yet succeeded in injecting the energy proportional to its resources into our intellectual life, because it has not yet attempted to develop the driving power which alone can save us from the disastrous results of having so recklessly sacrificed the heritage of youth. The majority of the graduates who yearly go out from the doors of our higher institutions of learning without any definite intellectual interests have passed directly from the period of adolescence to that of old age.

The intellectual vigor of the average college graduate has been dwarfed by the conventional system of education, in which the spirit of dogmatism in teaching crowds out most of the natural impulses to learn. He is not given a moment in which to develop any ardor for the pursuit of knowledge. Little emphasis is given in the curriculum to the value of research, and this lack destroys initiative and smothers individuality by catering to the wishes of those educational promoters who are always eager to gain prestige by organizing personally conducted parties in search of liberal education and general culture. Another very serious defect in the curriculum of our universities is shown in the effort made to protract the period of training the acquisitive functions at a time when the initiating and productive capacity of the student should be developed to the highest degree possible. The most productive years of the average student in our universities are now wasted in copying models at a time when they should be encouraged "to block out their own ideas."

There is no civilized nation which should be as optimistic of its intellectual development as the United States. The fact that ideas and ideals have not been completely crushed out of existence by the perpetuation of school methods during the university years is the best testimony that the innate qualities of the American mind have extraordinary powers of growth even among most unfavorable environments. The relation of the alma mater to the majority of college students is that of the governess to pupils, deliberately sacrificing vigorous mental traits for drawing-room accomplishments. Our American higher institutions of learning pay far too much attention to the cultivation of mere forms of thought, and have neglected the study of the mechanism and laws of thought production.

The period of vigorous manhood is, as has already been indicated,

characterized by a keen interest in the advancement of learning. Those who do not comprehend or sympathize with the investigator are deficient in the mental traits which are preeminently characteristic of the normal individual during the prime of life, and express the highest aspirations of our race. The chief value of research to a university is to be found in the presence of a body of men who, in spite of their years, retain their interest and progressive ideas longer than those who have more sympathy with the methods of the pedagogue than with those who are desirous of learning. We may best maintain the traditions and the highest instinctive tendencies of our race by encouraging productive scholarship. In a brilliant passage, the author of the "Foundations of the Nineteenth Century" has shown that the spirit of discovery is the conscience of Teutonic learning. When our energies are restricted merely to familiarizing ourselves with the learning of the past, or in attempting to enter the domain of speculative thought in which the Greek intellect reigned supreme, we throw away our heritage and precipitate conflicts between inherited and acquired trends of thought that often end in intellectual apathy. In order to vitalize the knowledge of a dead past, we must inject into it the spirit of discovery which alone reflects the highest aspirations of our race. The lack of idealism and the spirit of indifference so often characteristic of the graduates of many of our universities is in a large measure the product of an educational system which, by ignoring objectivity in teaching and failing to cultivate the spirit of enquiry, has ignored the underlying trends of thought that, if properly directed, can bring us nearer to the ideals compatible with our social traits. To endeavor to satisfy the intellectual needs of our race by continually repressing the spirit of enquiry and by driving students to contemplative reflection upon the accumulated stores of knowledge, is equivalent to exchanging the driving force or spirit, that is born in us, for a suit of clothes. When the specific racial tendencies reflected in the spirit of discovery are not intelligently directed they find expression in utilitarian motives. By attempting, as does our educational system, to force American students to become passive recipients of knowledge, we are asking them to sell their heritage for a mess of pottage.

When once the essential distinction that exists between university and college is grasped, it is necessary to determine to what extent the present system of organization is favorable or antagonistic to the development of these two different types of institutions. An impartial examination of the facts such as is given in the excellent exposition of this entire subject by Cattell[1] shows how extremely difficult it will be for most of the older institutions which have assumed the name of university to prove their right to this title. As has already been pointed out, the present system of administration is adapted merely to

[1] *Science,* May 24 and 31, 1912.

the perpetuation of the college spirit and traditions. We have seen that the college without radical administrative reorganization can not "grow into" the university. The supposition that the natural development of the former will, according to the laws of growth, expand into the latter, is an assumption that has resulted in an unnecessary conflict of ideals; as those of the two institutions are not interchangeable. The unfortunate state of affairs is exemplified in more than one of our eastern universities, where we see the members of administrative boards, thoroughly imbued with the collegiate idea, attempting to carry out educational policies that do not conform with the ideals of members of the faculties, who have had greater opportunities for familiarizing themselves with university standards. When the attempt is made to effect a compromise, the efficiency of both institutions is seriously impaired and results in an interminable conflict of interests. The trustees who, as a rule, are unfamiliar with the nature of the university problems, often control its policy through the administration of the finances, even determining the election of presidents and the distribution of sums for educational purposes. As a result of this usurpation of powers the faculty is in danger of becoming merely a body of employees of the trustees, without any power to shape the educational policy of the institution.

The increased emoluments and the excessive prominence bestowed upon executive officers have had a disastrous effect in detracting from the appraised value of the work of scholar and investigator. The great eagerness with which administrative offices are sought for by members of the faculty show how extremely superficial are their intellectual interests. One can not imagine a Momsen, Pasteur or Darwin deliberately putting aside his special investigations in order to become an administrator.

The present system of organization has resulted in a temporary but, nevertheless, serious depreciation of the estimated value of scholarship; and has also given rise to an extreme spirit of Chauvinism, inimicable to the development of those mental qualities that underlie true culture. In executing a plan for the development of the university, boards of trustees defer largely to the wishes of the alumni of the institution. On account of the great and constant influence exerted by the large body of alumni, the older institutions in the east will find that it is increasingly difficult for them to identify their interests with those of the national life. Admirable as are a few of the influences which grow out of the "college spirit," there is a great deal that is objectionable and affords a suitable medium for the development of fixed ideas. The intense emotional reactions of the undergraduates and their more or less absurd sentimental devotion to the standards of a single institution give rise to conditions not specifically different from those that give fixity and undue valuation to many of the ideas characteristic of hys-

terical or paranoid states. When the public fully realizes that the development of the spirit of intelligent criticism should be one, if not the chief, end of education, it will become obvious that it is very difficult to attempt to bestow the elements of a liberal education in the collegiate atmosphere. One may quite as well expect the spirit of truth-telling to be acquired in an atmosphere permeated by falsehood as to believe the acquisition of mental balance is possible in surroundings in which feeling and sentiment dominate judgment and reason. The extreme partisanship cultivated in undergraduate life dominates many of the undertakings of the post-graduate, and its evil effects are particularly noticeable in the parochial character of administration of the professional schools (theology, law and medicine).

The entire intellectual life of our higher institutions of learning, and in time of the nation, would be revivified if the administration of these institutions were reorganized in order to meet the following conditions. (1) A clear understanding of the essential difference between college and university. (2) The determination by the administrative boards of these institutions to adopt a policy which shall be compatible with the ideals of either college or university, and not represent an unfortunate series of compromises ending in hopeless mediocrity. (3) A public confession of faith as to the value of intellectual ideals by repeated public affirmations, as expressed in words and deeds, to the effect that it is always more difficult to secure the services of great scholars than it is to obtain funds to be expended in bricks and mortar. (4) The establishment of democratic ideals of government in a form of organization which shall not be dominated by the autocracy of president and deans nor by an oligarchy of trustees; and finally (5) The substitution of national ideals of efficiency for the narrow local prejudices which so frequently restrict the life and sphere of usefulness of our universities.

Many of these reforms may readily be introduced by bringing the trustees and overseers into closer touch with the faculty, so that there may be a more direct exchange of views on important questions; and by the reorganization of the former bodies, so that the members may be made familiar with the aims and ideals of the university.

If our eastern universities persist in continuing their present parochial forms of administration, within the next decade we shall see a multiplication of independent foundations forming the nuclei or centers of university work. Half a century hence there will probably be a resurrection of the older and privately endowed colleges as state universities.

PROFESSOR EDMUND B. WILSON,

Professor of Zoology, Columbia University, President of the American Association for the Advancement of Science.

THE PROGRESS OF SCIENCE

THE CLEVELAND CONVOCATION WEEK MEETING

There was an excellent meeting of the American Association for the Advancement of Science and of the affiliated national scientific societies at Cleveland during the week of January first. The scope and magnitude of their work can be indicated by a statement of the number of papers on the program for the different sciences, namely:

Mathematics	49
Astronomy	35
Physics	52
Engineering	40
Geology	27
Zoology	84
Entomology	73
Botany	60
Phytopathology	49
Horticulture	53
Anthropology	27
Psychology	56
Biological chemistry and pharmacology	63
Anatomy	63
Physiology	67
Education	11
Economics and Sociology	13
Total	822

In no other country except Germany could there have been brought together such an extensive series of papers nearly every one of which was based on research work and contributed to knowledge. Such a program demonstrates an extraordinary extension of scientific work in the United States in the course of the past twenty years. It may appear that men of great distinction and contributions of noteworthy importance were not represented in proportion to the total number of those who read papers. But this is in part due to the circumstance that one does not see the trees on account of the forest. If the only advances made in science during the past year were represented by a dozen of the papers taken at random from the Cleveland program, each one of them would appear to be an important scientific contribution.

It is noticeable that the different sciences represented on the program contributed papers not far from equal in number, even though the sciences themselves may vary greatly in importance and in the number of its workers. Fifty to seventy papers are about as many as can be presented in a three-days' meeting, and most of the societies had about so many. Thus phytopathology was as largely represented as botany, entomology as zoology, physiology as physics. This seems to demonstrate the value of scientific organization, for if there had not been societies for the presentation of these papers, it may be that the work would never have been done.

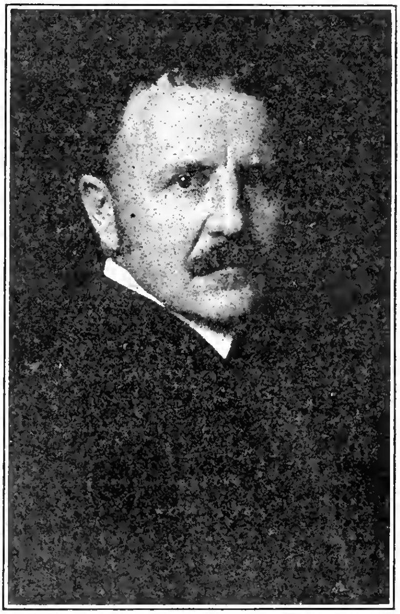
There are several cases in which the program does not adequately represent the scientific work of the country. Thus the engineering societies do not meet with the association and the section of engineering is weakened. This year the chemists decided to meet separately like the engineers, partly because New Year's week, chosen as a time when college and university men can be present, is inconvenient for those engaged in industrial work. It seems desirable to increase rather than to decrease the contact of the pure and applied sciences, and it may be hoped that joint meetings may be arranged, perhaps at periods of three years. In that case the national societies devoted to economics, history and philology might also join in a great convocation

week meeting, which would impress on those present and on the public the magnitude and weight of the work being accomplished for science and scholarship.

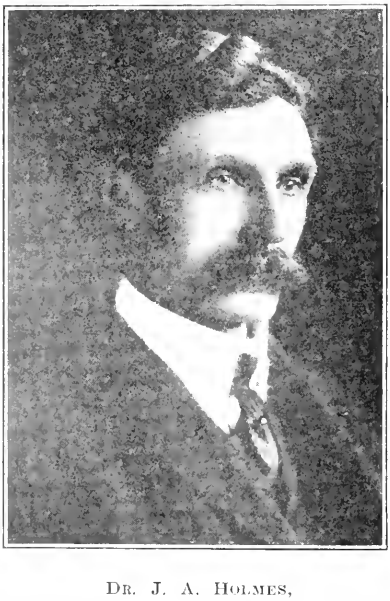
The American Association for the Advancement of Science and its affiliated societies have failed to accomplish as much as the British Association for the diffusion of science and in bringing together those engaged in scientific research and those who are or might become interested. Programs of general interest were arranged at Cleveland by nearly every section, but the attendance was practically confined to scientific men. Such meetings should be brought to general attention by full accounts in the local press and by reports throughout the country, but here almost complete failure must be confessed.

The council of the association took several steps intended to improve its

Dr. E. B. Van Vleck,
Professor of Mathematics at the University of Wisconsin, Vice-president for Mathematics and Astronomy.



Dr. William A. Locy,
Professor of Zoology at the Northwestern University, Vice-president for the Section of Zoology.



Dr. J. A. Holmes,
Director of the Bureau of Mines, Vice-president for the Section of Geology.

organization. The members on the Pacific coast, who number about 500, were authorized to make arrangements for a general meeting at the time of the Panama Pacific Exposition of 1915, and if they see fit to hold annual sectional scientific meetings. All institutions engaged in scientific research were requested to send delegates to the convocation-week meetings, paying their expenses when possible. In addition to the permanent secretary and the assistant secretary there was made provision for an associate secretary, who

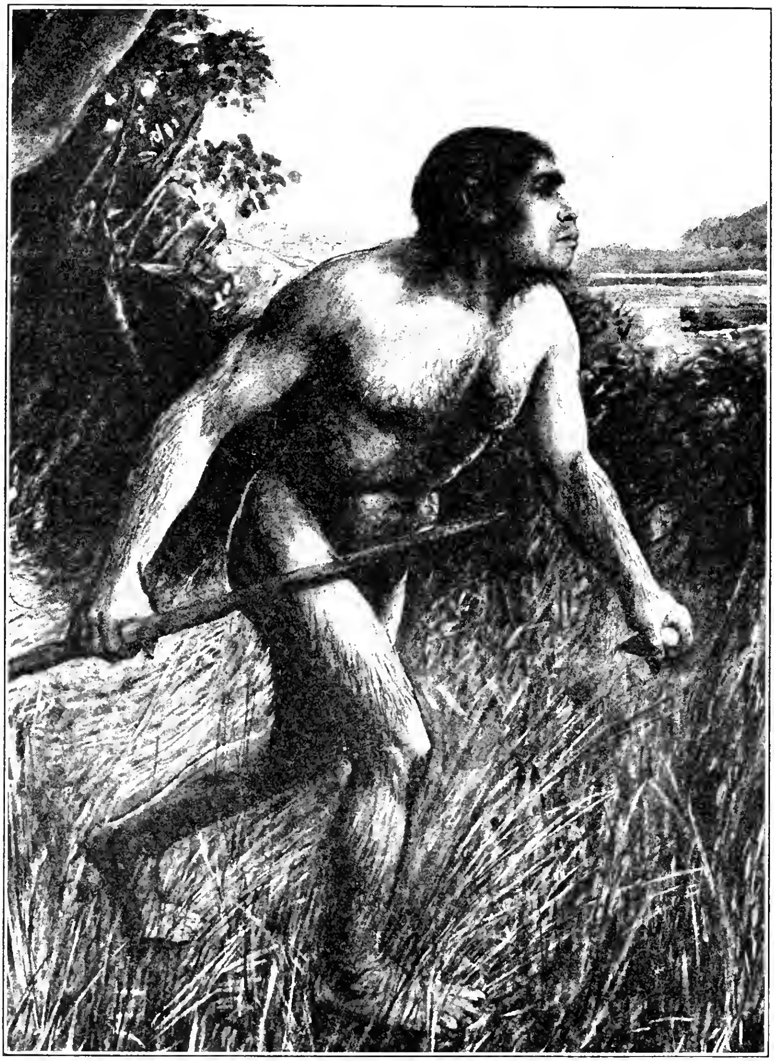
JOHN HAYS HAMMOND, LL.D., Vice-president of the Section of Social and Economic Science.

DR. DUNCAN S. JOHNSON, Professor of Botany at the Johns Hopkins University, Vice-president for the Section of Botany.

shall devote his entire time to the association and to the organization of scientific men.

The high scientific standing of the men responsible for the conduct of the work of the association is shown by the officers annually elected. We are able to reproduce here portraits of several of those who presided over the sections at the Cleveland meeting. The president of the association, Professor Edward C. Pickering, director of the Harvard College Observatory, is able to transfer this high office to Professor

DR. J. J. R. MCLEOD, Professor of Physiology at the Western Reserve University, Vice-president for the Section of Physiology.

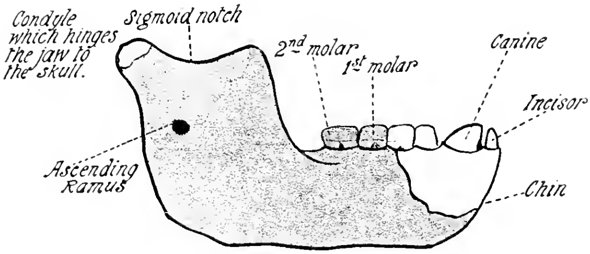


RECONSTRUCTION OF *Eoanthropus dawsoni.*

E. B. Wilson, professor of zoology at Columbia University. So long as the association is able to select presidents such as these, it bears witness to the fact that this country possesses men who unite scientific genius with personal distinction. The next convocation-week meeting will be at Atlanta; two years hence Philadelphia is proposed.

AN EXTINCT SPECIES OF MAN

AN anthropological discovery, rivalling in importance the discovery of *Pithecanthropus erectus* in Java by Dr. Du Bois twenty years ago, was communicated to the London Geological Society last month by Mr. Charles Dawson and Dr. A. S. Woodward, the keeper of the Geological Department of the British Museum. It appears



JAW OF *Eoanthropus dawsoni.*

that some four years ago Mr. Dawson noticed that a road had been recently mended by peculiar flints, and on tracing them to their source, he found that the laborers had dug out an object looking like a cocoa-nut, which they had thrown on a rubbish heap. This proved to be part of a human skull, and excavations of the undisturbed gravel where it was found discovered part of the jaw bone. A somewhat absurd cablegram was sent the newspapers in this country reporting the discovery of a fossil man who could reason before he could speak. But it is the case that the cranium is on the whole human in its characteristics, while the jaw tends to be simian.

A restoration of the jaw by Dr. W. P. Pycraft, of the British Museum, is here given, and a more fanciful reconstruction of the primitive man, drawn under his direction by Mr. Forestier for the *Illustrated London News.* The remains were found on a plateau 80 feet above the river bed, to which extent denudation had taken place since the gravel was formed. In it were also found the remains of extinct mammals and many water-worn, iron-stained flint artifacts, to which the term eoliths has been applied. The gravel is early pleistocene, near enough to pliocene to make it almost certain that the immediate ancestors of the pleistocene man must have lived during that period.

The cranium is fragmentary, but typically human, with a capacity of over a thousand cubic centimeters, indicating a brain about four fifths that of the average European and twice as large as that of the highest apes. The bones are remarkably thick and the temporal muscles extend higher up on the skull than in any recent or fossil man. The jaw bears some resemblance to the Heidelberg jaw, but it is less massive, with a still more negative chin and other simian features. As restored it is much like that of the chimpanzee. Dr. Woodward regards the remains as belonging not only to a hitherto unknown species, but has erected for it a new genus to which the name *Eoanthropus dawsoni* has been given. Recent discoveries prove that primitive man at a period from one hundred thousand to a million years ago was widely spread over Europe and apparently as far as Java, and that different species and perhaps genera may have lived simultaneously in different regions.

THE SEALS OF THE PRIBILOF ISLANDS

PRESIDENT TAFT has sent a special message to the congress recommending the repeal of the law passed on February 15 of last year prohibiting the killing of seals on the Pribilof Islands for five years. His recommendation and that of the experts of the government should certainly be followed by the congress. A clear statement of the whole situation, drawn up by Dr. David Starr Jordan and Mr. G. A. Clark, has been recently given out by the Bureau of Fisheries of the Department of Commerce and Labor. The Pribilof Islands in Bering Sea came into the possession of the United States in 1867, and our

government has received about ten million dollars in royalties paid on seal skins. At the time of the transfer to the United States, the herd numbered about two and a half million animals, but has now been reduced to about one tenth of that number. The decline was due to pelagic sealing which took advantage of the migration journeys and distant feeding habits of the seals to kill them in the open sea. In 1894 about 60,000 animals from the Pribilof herd were killed in this way, mostly females with unborn young or with pups in the rookeries. It is said, further, that from a half to three quarters of the seals shot in pelagic sealing are never recovered.

Many efforts were made to do away with the evils of pelagic sealing, and finally in 1911 a treaty was drawn up according to which the United States and Russia, as owners of the principal fur seal herds, agreed to pay to Great Britain and Japan fifteen per cent. each of the product of their land-sealing operations, on condition that pelagic sealing be abolished by those nations for fifteen years. If no seals are killed on the Pribilof Islands, the treaty would be practically made of no effect, and one might expect pelagic sealing to be resumed. It is also true that those best informed on the subject hold that the killing of superfluous bulls is a real advantage to the herd. The seal is a polygamous animal, each bull having an average family of fifty cows. Fear of the adult males causes the young males to herd by themselves, and they may be driven away and handled like cattle. If there are too many bulls, there is continuous fighting, and the pups are killed. The conditions are somewhat similar to those in the raising of cattle, the experts wishing to use the methods commonly in vogue, whereas the suspension of the killing of superfluous males would lead to the condition in which calves are being raised in a field in which there are a hundred cows and a hundred bulls.

It is certainly to be hoped that the congress will accept the recommendation of President Taft and its own experts and not interfere with the proper interpretation of the treaty of 1911 and the best treatment of the seal herd of the Pribilof Islands.

SCIENTIFIC ITEMS

We regret to record the death of Dr. Lewis Swift, formerly director of Mt. Lowe Observatory, known for his discoveries of comets and nebulæ; of Mr. Samuel Arthur Sanders, a British astronomer, and of Mr. William G. Tegetmeier, the English naturalist.

The national scientific societies at the recent convocation-week meetings elected presidents, as follows: the American Physical Society, Professor B. O. Peirce, of Harvard University; the Geological Society of America, Professor Eugene A. Smith, professor emeritus of the University of Alabama and state geologist; the Society of American Bacteriologists, Professor C. E.-A. Winslow, of the College of the City of New York; the American Botanical Society, Professor D. H. Campbell, of Stanford University; the American Anthropological Association, Professor Roland B. Dixon, of Harvard University; the American Psychological Association, Professor C. H. Warren, of Princeton University; the Society of the Sigma Xi, Professor J. McKeen Cattell, of Columbia University; the American Society of Naturalists, Professor Ross G. Harrison, of Yale University; the American Economic Association, Professor David I. Kinley, of the University of Illinois; the American Historical Association, Professor William A. Dunning, of Columbia University.

It has been proposed to municipal authorities of Paris that the memory of Henri Poincaré should be honored where he taught, and it is suggested that the portion of the Rue Vaugirard between the Boulevard St. Michel and the Odéon should be named after him.

THE POPULAR SCIENCE MONTHLY.

MARCH, 1913

HENRI POINCARE AS AN INVESTIGATOR[1]

By Professor JAMES BYRNIE SHAW

UNIVERSITY OF ILLINOIS

IT has not seemed to me appropriate, nor would there be time, nor should I be able, to enter into an exhaustive study of the life-work of a master-mind like Jules Henri Poincaré. Indeed, to analyze his contributions to astronomy needs a Darwin; to report on his investigations in mathematical physics needs a Planck; to expound his philosophy of science needs a Royce; to exhibit his mathematical creations in all their fullness needs Poincaré. Let it suffice that he was the pride of France, not only of the aristocracy of scholars, but of the nation. He was inspired by the genius of France, with its keen discernment, its eternal search for exact truth, its haunting love of beauty. The mathematical world has lost its incomparable leader, and its admiration for the magnitude of his achievements will be tempered only by the vain desire to know what visions he had not yet given expression to. Investigators of brilliant power for years to come will fill out the outlines of what he had time only to sketch. His vision penetrated the universe from the electron to the galaxy, from instants of time to the sweep of space, from the fundamentals of thought to its most delicate propositions.

In his funeral oration, Painlevé, speaking for the *Académie des Sciences,* said:[2]

> He was only twenty-four years of age, when after four years of silent and sustained reflection, he began the series of mathematical publications which leaves us in doubt whether to admire most its surprising profundity or its surprising fecundity.
>
> Whether he attacked the ascension, step by step, of the truths of arithmetic discontinuity, or unloosed the tangle of geometric form, or followed the subtlest

[1] For a biographical sketch of Poincaré, see *Revue des deux Mondes,* 1912, September 15. Also the second edition of Lebon's book on Poincaré has appeared.

[2] *Revue du Mois,* Vol. 7 (1912), p. 133.

windings and caprices of the continuous laws that join quantities together, there is not one of his works which has not the masterly touch, not one of his fifteen hundred publications which does not show the lion's claw.

At the age of twenty-seven, the Faculty of Sciences offered this young conqueror its chair of physical mechanics. At thirty-three the Academy of Sciences opened its door, an example soon followed by the learned academies of the entire world; for there was no body of scientists in Europe or America which did not feel that it honored itself in adjoining the cooperation of Henri Poincaré.

But the mathematical sciences were for this illustrious analyst only a manifold and prodigious measuring instrument admirably adapted to the comparative study of the phenomena of the universe. This instrument he set himself to use, and what skill he displayed! At the age of thirty, he astonished the physicists by his critique of the general principles of their science; that was but the beginning of bold speculations which led him year by year up to the very edge of the unknown, to the constitution of matter, to the paradoxical mechanics that sprung up after the unexpected discovery of the mysterious radioactivity.

Yet this was only part of his activity: geodesy, cosmogony, astronomy, philosophy of science, he included them all, penetrated all, explored all. His celestial mechanics would be glory enough. It was this that revealed him first to a wide public. King Oscar II. of Sweden, Mæcenus of science, enlightened and generous, in 1887 opened an international competition in mathematics. In 1889, at the end of the contest, France learned with joy that the great gold medal, supreme prize of this new tournament, had been awarded to one of her children, a young scientist thirty-five years of age, for a marvelous study of the mechanical stability of our universe; and the name of Henri Poincaré was famous.

Gentlemen, the Theban hero dying after two victories said: "I leave two immortal daughters." This hero of the world of thought who has just succumbed, leaves in the ideal world, as real as the other world, an immortal posterity which will guide the future researches of men. Indeed his life will remain an example as harmonious in its faultless lines as the orbits of those stars whose eternal past and eternal future he desired to know.

To this eulogy of Professor Painlevé certainly I could add nothing, and it does not seem necessary to enumerate the many other honors of Poincaré's. I shall undertake only to consider briefly his conception of science in its chief phases, and in the light of this conception to consider at more length in particular his ideas of research. As an investigator his opinions carry extraordinary weight, as he was a subtle philosopher and a skilled psychologist. We may treat three phases of scientific activity as distinct, pure science, industrial science and what we may call euthenic science.

In speaking of the death of Brouardel,[3] who did much for the study of hygiene, and had helped in preventing three invasions of cholera, without disturbing commerce, Poincaré said before the *Académie des Sciences:*

In this direction scientists can scarcely count on the satisfaction of discovering general laws, exterior as it were to space and time, but there are other

[3] *C. R.*, 143 (1906), p. 996.

joys and above all that of doing good immediately to humanity and correcting evils without forcing the remedy to wait.

The scientist is accustomed to conquer truth only by degrees; for him all certainty should be bought by long hesitations, by perpetually feeling his way. He suspects what comes too easily, and accepts it only after submitting it to numerous and diverse proofs. The man who must act can not embarrass himself by such scruples. He cares little for a truth which must wait so long, because it may arrive too late, and after the moment for action has passed. He must make rapid conquests; sometimes these are not the most durable nor those we should esteem. He also has to avoid reefs which we know not, we for whom time does not count, and sometimes we are tempted to say a true scientist ought not to risk them; how much better on the contrary to congratulate ourselves that there are men skilful enough to avoid them.

Towards pure science his attitude was almost adoration. It is best set forth by extracts from his "Value of Science" and "Science and Method":

The search for truth should be the goal of our activity; it is the only end worthy of it. . . . When I speak here of truth doubtless I mean primarily scientific truth, but I wish to speak also of moral truth, one of whose aspects is what we call Justice. . . . To find one as well as to find the other, it is necessary to struggle to the utmost to free ourselves from the bonds of prejudice and passion, to attain absolute sincerity.

The best expression of the harmony of nature is Law. Law is one of the most recent conquests of the human mind. Man demands that his gods prove their existence by miracles, but the eternal marvel is that there are not miracles all the time. And the world is divine because it is harmonious. Were it ruled by caprices what could ever prove it due to aught but chance?

But does this harmony which the human intellect believes it finds in nature exist outside the intellect? Doubtless not; a reality completely independent of the mind that conceives it, sees it, feels it, is an impossibility. What we call objective reality is, in the last analysis, what is common to many thinkers and could be common to all; this common part, we shall see, can be only the harmony expressed by mathematical laws.

So we conclude that this harmony is the sole objective reality, the sole truth we can ever attain, and if I add that the universal harmony of the world is the source of all beauty, it becomes comprehensible how we should prize the slow and painful progress by which we learn little by little to know it.

The scientist does not study nature because it is useful; he studies it because it pleases him, and it pleases him because it is beautiful. Were nature not beautiful, it would not be worth knowing, life would not be worth living. I do not mean here, of course, that beauty which impresses the senses, the beauty of qualities and appearances; not that I despise it—far from it; but that has nought to do with science; I mean that subtler beauty of the harmonious order of the parts which pure intellect appreciates. This it is which gives a body, a skeleton as it were, to the fleeting appearances that charm the senses, and without this support the beauty of these fugitive dreams would be but imperfect, because it would be unstable and evanescent. On the contrary intellectual beauty is self-sufficient and for its sake, rather than for the good of humanity, does the scientist condemn himself to long and tedious labors.

In connection with this view of the scientist in his own domain, I desire to quote also from the preface of the recent second German edition of "Value of Science," which expresses his attitude towards industrial science:

> Science has always had to contend with skeptics and scoffers who were quite ready to draw conclusions from relative failures and temporary inactivity, and to note the confessions of scientists who admit that the field of science is bounded, but fail to add that inside its own realm it is supreme.
>
> He who views scientific work from the outside is often amazed to see yesterday's truth so easily become to-morrow's error. He believes then, that our conquests are over-confident, that the principles so proudly paraded are only novelties, and he does not see that beneath these necessary changes of form scientific truth is always one and the same. It remains eternally unchanged and only the clothing in which we deck it out changes with the fashion.
>
> Fortunately science is needed in applications, and this silences the skeptic. If he desires to use some new discovery, and convinces himself of its success, he must indeed admit that it is more than an idle dream. We thus perceive the blessing which lies in the development of industry.
>
> I do not wish to say that science is created for its applications, far from it; one must love it for its own sake; but the recognition of its applications protects us from the skeptic.

Poincaré's conception of science can be summed up in these terms: Science consists of the invariants of human thought.

In the field of investigation, the important thing for Poincaré was the discovery of the real relation between isolated facts. The important facts are those that suggest relations. We select facts from this standpoint. The world of relations was as real to him as the world of phenomena, and so far as we know the real relations, in whatever language we express these relations, just so far we know the actual world, the objective world. Even absolute space and absolute time do not exist, these two are relations furnished by our own minds.[4] Thus the term energy, and our notion as to the existence of energy, may change in the course of time, but the persistent relation that gives us our present notion of energy is real and does not change. It may be true, as Herschel said, that in the twinkling of an eye a molecule solves a differential equation which if written out in full would belt the globe, but the molecule knows nothing of the equation—that is created by the mind, and as the modern discontinuous physics develops, it may be that we shall have to use difference equations rather than differential equations. But the differential equation expresses certain persistent relations between phenomena, and is thus real, and is the replica of an objective reality. The differential equation means that the phenomenon is one such that each state is the result of the immediately preceding state; the new integro-differential equation of Volterra means that the state is due to all the preceding states; the difference equation means that the states follow each other

[4] *Scientia*, 12 (1912), 159–171 (posthumous).

abruptly; and integro-difference equations would mean that they depend on all preceding states discontinuously. Each is able to account for certain relations in the states. In the same sense the word atom is the name for a set of relations, and though it may change and the atom itself become a solar system, yet what we really mean by the atom is permanent and represents an objective reality. We are witnesses too of an evolution in science and mathematics from the continuous to the discontinuous. In mathematics it has produced the function defined over a range rather than a line—a chaos, as it were, of elements—and the calculable numbers of Borel. In physics it has produced the electron, the magneton, and the theory of quanta,[5] about which Poincaré said shortly before his death:

> A physical system is capable of only a finite number of distinct states; it abruptly jumps from one state to another without passing through the intermediate states.

In biology we have the corresponding theory of mutations. Yet despite this apparent reduction of old ideas into dust, contradictory to our hopes of its permanence; as Poincaré put it: this is right and the other is not wrong. They are in harmony, only the language varies; both set forth certain true relations.

Just as Maxwell and Kelvin were able to invent mechanical models of the ether, so Poincaré is perhaps the most profound genius the world has ever known in devising the more subtle machinery of thought to represent the relations he found not only between numbers and geometric figures, but between the phenomena of physics. His mind seemed to create new structures of this kind continually, finding expression for the most intricate relations. Nowadays this is the same as saying that he was a mathematician, for this ideal world of relations is the one with whose structure mathematics is concerned, and which mathematics claims sovereignty over, verifying Gauss's assertion: "Mathematics is Queen of all the Sciences."

In the address of Masson when Poincaré was made one of the forty immortals, he said:

> You were born, you have lived, you will live, and you will die a mathematician; the vital function of your brain is to invent and to resolve more cases in mathematics; everything about you relates to that. Even when you seem to desert mathematics for metaphysics, the former furnishes the examples, the reasoning, the paradoxes. It is in you, possesses you, harries you, dominates you; in repose, your brain automatically pursues its work, without your being aware of it—the fruit forms, grows, ripens, and falls, and you have yourself told us of your wonder at finding it in your hand so perfect. You furnish an admirable example of the mathematical type. Since Archimedes it is classical but legendary. Rarely will historian have found an occasion so fit to note in life its external characters, and in place of relating your works, rather is not this

[5] See *Jour. de Physique*, 1912 (5), 2; pp. 5–34; 347–360.

the occasion to see how mathematical genius manifests itself, whether it is the result of atavism, or the product of a special culture, at what moment and under what conditions it sees light, at what epoch of life it is most active and brilliant?

Fortunately the answer to Masson's question is to be found in Poincaré's own writings, and it becomes the more interesting when taken in connection with his further thesis that the method of research in mathematics is precisely that of all pure science. This method I desire to consider at some length, for I conceive that such a consideration will be entirely appropriate in this place.

The first research mentioned by Rados in the report of the committee to the Hungarian Academy in 1905, when Poincaré was awarded the first Bolyai prize as the most eminent mathematician in the world, is the series of investigations relating to automorphic functions. These functions enable us to integrate linear differential equations with rational algebraic coefficients, just as elliptic functions and abelian functions enable us to integrate certain algebraic differentials. With regard to these researches, Poincaré tells us that for a fortnight he had tried without success to demonstrate their non-existence. He investigated a large number of formulæ with no results. One evening, however, he was restless and got to sleep with difficulty; ideas surged out in crowds and seemed to crash violently together in the endeavor to form stable combinations. The next morning he was in possession of the particular set of automorphic functions derived from the hypergeometric series; he had only to verify the calculations. Having thus found that functions did exist of this kind, he conceived the idea of representing these functions as the quotients of two series, analogous to the theta series in elliptic functions. This he did purely by the analogy, and arrived at theta-fuchsian functions. Having occasion to take a journey, mathematics was laid aside for a time, but in stepping into an omnibus at Coutances, the idea flashed over him that the transformations which he had used to define these automorphic functions were identical with certain others he had used in some researches in non-euclidean geometry. Returning home he took up some questions in the theory of arithmetic forms, and with no suspicion that they were related to the fuchsian functions or the geometric transformation, he worked for some time with no success. But one day while taking a walk, the idea suddenly came to him that the arithmetic transformations he was using were essentially the same as those of his study in non-euclidean geometry. From this fact he saw at once by the connections with the arithmetic forms that the fuchsian functions he had discovered were only particular cases of a more general class of functions. He laid siege now systematically to the whole problem of the linear differential equations and the fuchsian functions and reached result after result, save one thing which seemed to be the key-

stone of the whole problem was stubborn. He was compelled to go away again to perform military duty, and his mind was full of other things. But one day while crossing the boulevard the solution of the last difficulty suddenly appeared and upon verification was found to be correct.

In this account of the birth and growth of mathematical development, which he assures us is practically the same as for all such developments, it is obvious that the central notion is that of generalization. Elliptic, abelian and theta functions are in turn generalized into a new class of transcendents. Inversion of differentials is generalized into inversion of differential equations. This notion of generalization we need to inspect a little closely. Mathematical generalization consists of two types of thought, often not discriminated, and often scarcely to be discriminated from each other. One type consists in so stating a known theorem that it will be true of a wider class than in its first statement, and the predicate asserted has a wider significance. In such generalization the first statement of the theorem becomes a mere particular case of the second statement. Examples will occur readily to every one. There are two forms of this type: in one, many known cases are brought together under one law; in the other form, the law thus found is made to apply to other known cases, perhaps never before suspected to be related to the first set. It is the guiding threads of analogy that usually bring about these forms of generalization. This kind of generalizing power Poincaré had in high degree. In his memoir on "Partial Differential Equations of Physics"[6] he says:

> If one looks at the different problems of the integral calculus which arise naturally when he wishes to go deep into the different parts of physics, it is impossible not to be struck by the analogies existing. Whether it be electrostatics, or electrodynamics, the propagation of heat, optics, elasticity or hydrodynamics, we are led always to differential equations of the same family; and the boundary conditions though different, are not without some resemblances. . . . One should therefore expect to find in these problems a large number of common properties.

Also in his "Nouvelles Méthodes de la Mécanique Céleste" he says:

> The ultimate aim of celestial mechanics is to solve the great question whether Newton's law alone will explain all astronomical phenomena.

In his address awarding Poincaré the gold medal of the Royal Astronomical Society, G. H. Darwin[7] said:

> The leading characteristic of M. Poincaré's work appears to be the immense wideness of the generalizations, so that the abundance of possible illustrations is sometimes almost bewildering. This power of grasping abstract principles is the mark of the intellect of the true mathematician; but to one accustomed rather to deal with the concrete the difficulty of completely mastering the argument is sometimes great.

[6] *Amer. Jour. Math.*, Vol. 12.

[7] "Scientific Papers," Vol. 4, p. 519.

In the account of the creation of the fuchsian functions we see this power of finding examples of his generalizations, that is to say, of applying them. By these functions he could solve differential equations, he could express the coordinates of algebraic curves as fuchsian functions of a parameter, he could solve algebraic equations of any order. Humbert put it succinctly thus: "Poincaré handed us the keys of the world of algebra." Again, from the simplification of the theory of algebraic curves he was able to reach results which led to a generalization of the fuchsian functions to the zetafuchsian functions, which he afterward used in differential equations, the starting point of the problem. He applied the theory of continuous groups to hypercomplex numbers and then applied hypercomplex numbers to the periods of abelian integrals and the algebraic integration of differential equations of certain types. He applied fuchsian functions to the theory of arithmetic forms and opened a wide development of the theory of numbers. He applied fundamental functions to the potential theory of surfaces in general, showing how the Green's function could be constructed for any surface, permitting the solution of the problem. He developed integral invariants, which persist through cycles of space and time. He dared to apply the kinetic theory of gases and the theory of radiant matter to the Milky Way itself, suggesting that probably we are a speck in a spiral nebula. He analyzed mathematically the rings of Saturn into a swarm of satellites, and the spectroscope confirmed his conclusions, a piece of work ranking with the mathematical discovery of Neptune. He found a generalization for figures of equilibrium of the heavenly bodies, discovering an infinity of forms and pointing out the stable transition shapes from one type to another, of which the piriform was quite new; at the same time throwing light on the problems of cosmogony. He applied trigonometric series, divergent series, and even the theory of probabilities, to show that the stability or instability of our universe has never been demonstrated, but that if probability is measured by continuous functions only, the universe is most probably stable.

There is no essential difference between generalizations of this type in whatever realm they appear. It is generalization to see that projective geometry merely states the invariancies of the projective group, and elementary geometry is a collection of statements about the invariants of the orthogonal group. Expansions in sines and cosines, or Legendrian polynomials, or Bessel functions are particular cases of expansions in fundamental functions, and these arise from the inversion of definite integrals. It is also generalization to reduce the phenomena of light to a wave-theory, then the phenomena of light, electricity and magnetism to ether-properties. It is generalization to reduce physics and physical chemistry to the study of quanta of energy, and, I might add, to reduce all the physical sciences to a study of the kinematics of four-dimensional

space. When we say natural law, we mean generalization of this type. The laws of science are generalizations of the relations between phenomena. According to Poincaré there are three classes of hypotheses in science: (1) Natural hypotheses, which are the foundations of the mathematical treatments, such as action decreases with the distance, small movements follow a linear law, effect is a continuous function of the cause, physical phenomena are discontinuous functions; (2) Neutral hypotheses, which enable us to formulate our ideas, and are neither verifiable nor unverifiable, such as the hypothesis of atoms or of a continuous medium; (3) Generalizations, invariantive relationships, which are valuable, may be verified by experiment and lead to real progress. In "Science and Hypothesis" his thesis is, that science consists of observed facts organized according to these three classes of hypotheses. In "Value of Science" the thesis is, that the objective value of science consists in the laws, that is, in the generalizations, discovered. In "Science and Method" the thesis is, that the discovery of laws is by methods substantially the same as those of mathematical investigation, deducing from a significant particular a wide-reaching generalization, selecting our facts because of their significance.

This type of generalization, however, is only a part of the mathematical generalization. It might in broad terms be characterized as the purely scientific type. The second type, which might be broadly characterized as the purely mathematical type, is that in which there is a distinct widening of the field of a conception, usually by the addition of new mathematical entities. Examples are the irrational numbers, negative numbers, imaginary numbers, quaternions and hypercomplex numbers in general. The name imaginary indicates the fact that the actual existence of these was once open to question in the minds of some. Other examples are the non-euclidean geometries, the non-archimedean continuity, transfinite numbers, space of four and of N dimensions. The ideal numbers of Kummer and the geometric numbers of Minkowski are generalizations mainly of this type. It is not possible to separate sharply this kind of generalization from the other, and it would often be difficult to say whether a given mathematical investigation belongs primarily to the one kind or the other. However, when an investigation does not merely utilize material that is already known, but introduces new objects for study whose properties are not known, we can classify it under the second type. Usually the second type arises from inversion processes. We have given certain properties to find the class of things satisfying them. If they do not exist we create them. Whether we consider that the new objects have (in mathematics) been created or discovered, is merely a matter of psychologic point of view. For example, in one of Poincaré's last papers[8] he explains the apparently irreconcil-

[8] *Scientia,* 12 (1912), pp. 1–11.

able difference of opinion which there is among mathematicians regarding the existence of a definable infinity as due to the difference in the psychology of the two classes. One, the idealistic, feeling that everything we define is due to the mind, and finite; the other, the realistic, feeling that there is an external world which may well contain an infinity. The idealistic class, to which Poincaré belonged, would consider that these extensions to which we referred are in a sense creations.

It is scarcely necessary to enumerate the creations of Poincaré. They are many, for he was gifted with extraordinary originality. The account given above of the creation of the fuchsian functions is an example of one of his most important. It opened an immense field of investigation. He created a type of arithmetic invariants expressible as series or definite integrals, which opened a new field in theory of numbers. His investigations of ordinary differential equations which are not linear, such as those in dynamics and the problem of N bodies, created an extensive class of new functions which (I believe) are yet without special names, as well as suggesting the existence of classes of functions for which we have, as yet, even no means of expression. The investigations of asymptotic expansions opened paths to dizzy heights. Fundamental functions in partial differential equations also open a region now under development. We may say that the most marvelous of his creations rise from the general field of differential equations. We might cite further his researches in analysis situs, the realm of the invariants of a battered continuity. His double residues and studies in functions of many real variables are creations from which will spring a noble progeny. Even the lectures in which he presented the results of others scintillate with original thoughts.

To generalize in mathematics and science it is not enough simply to get together facts or ideas and to put them into new combinations. Most of these combinations would be useless. The real investigator does not form the useless combinations at all, but unconsciously rejects the unprofitable combinations. It is as if he were an examiner for a higher degree; only the candidates who have passed the lower degrees ever appear before him at all. Often domains far distant furnish the useful combinations, as in the account given of the genesis of the fuchsian functions, the theory of arithmetic forms through the roundabout route of non-euclidean geometry furnished the generalization of the first fuchsian functions to the complete class. This was of the first type. But how are those of the second type born?

We come thus to the heart of the matter. Merely to say that we discover laws is not sufficient. How do we discover extensions? How devise new formulæ? Make new constructions? The answer to this question is, for Poincaré, found in psychology. It is necessary to get together many facts, but this does not insure that we shall build with

them any more than that a collection of beams and stones will make a cathedral. Mere haphazard construction does not produce the cathedral either. To reach the end it is necessary to have the end in view from the beginning. It is not only necessary to choose a route, but we must see that it is the route to be chosen. This implies a power of the mind which Poincaré calls intuition. It is that power which enables us to perceive the plan of the whole, to seize the unity in the matter at hand. This power is necessary not only to the investigator, but it is also necessary—in less degree, perhaps—to him who desires to follow the investigation. Why is it, he asks, that any one can ever fail to understand mathematics? Here is a subject constructed step by step with infallible logic, yet many do not comprehend it at all. Not on account of poor memory—that may lead to errors in calculation, but has little to do with comprehension of the subject. Sylvester, for example, was notorious for his inability to remember even what he himself had proved. It is not due to lack of the power of attention, for while concentration is necessary in the development of a demonstration, or in following a piece of logic, it does not give this appreciation of mathematics. A mathematical demonstration is a series of inferences, but it is above all a series of inferences in a certain order. The important thing is the order, just as in chess the mere moving according to the rules is not enough, it is the plan of the game that counts. If one appreciates it, this order, this plan, this unity, this harmony, he need have no fear of a poor memory, nor need he weary his concentration. The student deficient in this power may learn demonstrations by heart, he may assent to each step as logically proved, yet he will know little of the theorem itself. Those who possess this kind of insight which reveals hidden relations, this divining power for the discovery of mines of gold, may hope to become investigators, creators. Those who do not have it must find it or give up the task. The great educational question of the day is the problem of the development of the intuition. If we learn to cultivate this spirituelle flower it will open all doors of invention and discovery of laws. It is an interesting problem for even the grade teacher. If it be true, as Boris Sidis and others have claimed, that there are superior methods of education (which seem really to lie along this line) then they must become the methods of future education. We will begin to educate for genius. One thing seems evident, that too prolonged adherence to the methods of rigid reasoning leads to sterility. In mathematics at least both logic and intuition are indispensable, one furnishes the architect's plan of the structure, the other bolts it and cements it together. Logic, says Poincaré, is the sole instrument of certitude, intuition of creation. Yet even the steps of a logical deduction are planned in their entirety by the intuition. In discussing the partial differential equations of physics[9]

[9] *Amer. Jour. Math.*, Vol. 12.

and their solutions, he points out that one often has to content himself with the guidance he can get by physical considerations. An example of this was the use made by Klein of electrical considerations in handling Dirichlet's problem on a Riemann surface. In the physical aspect of the problem this would usually be sufficient, for the physical data are at the best only approximate. The mathematical necessities of convergence demand, however, that the problems be handled purely analytically and deductively. In one of his lectures he compares the process with the formation of a sponge. When we find it fully formed it is only a delicate lace-work of needles of silica. But the really interesting thing is the form it has taken, and this can be fully understood only by knowing the life-history of the sponge which has impressed its form, its will, so to speak, on the silica. In the same way a logical development of a theorem can really be understood only through a study of its living development. Need we point out the significance of this to the research student? Just as a painter who would become great must sit at the feet of a master and see his creations grow on the canvas, so the student does well to watch a master at work on scientific creations. This is the good he gets at the university. No compendium of results of the great creators will suffice. Nor is a too detailed study of the history of a problem, or too extensive a list of its bibliography, of assistance to the intuition. These might assist the later logical development, but not the inventive power. Poincaré rarely did more than to acquaint himself with the present status of a problem he desired to consider. It is evident too that the intuition is *sui generis,* and guidance of it in the seminar must simply stimulate, not undertake to determine its form. The investigator must set his own problem and work it out in his own way. The director of research should furnish favorable surroundings and set forth the matter of his lectures in as genetic form as possible, as for example, Poincaré's and Klein's masterly courses. But he should not prescribe forms of development, nor methods of attack for the novitiate.

The types of intuition are numerous. We leave to the psychologist their enumeration and description. For example, we should expect a visualist to think in pictures, for in this direction his imagination would be vivid. Such a mind would make use of diagrams and mechanical forms to embody his ideas. We think at once of Faraday and his lines of force, of Kelvin and his models of the ether. Poincaré compares Bertrand and Hermite, schoolmates educated at the same time in the same way. Bertrand when speaking was always in motion, apparently trying to paint his ideas. Hermite seemed to flee the world, his ideas were not of the visible kind. Weierstrass thought in artificial symbols, Riemann in pictures and geometric constructions. Poincaré is spoken of as belonging to the audile type, for he remembered sounds well.

He seems from his memoirs and papers, however, also to be equally of the visual and the symbolic types. He valued words highly, and his style is a mountain brook descending from rarefied heights, its clear current here falling over rocks, there gliding smoothly down. His thought is a penetrating ray that illuminates the deepest recesses of the wilderness of phenomena.

But in any case, whether one be analyst, physicist, biologist or psychologist, the characteristic trait of the intuition is the direct appreciation of relationships between the objects of thought, which unite them into a complete structure, unitary in character and harmonious in form. We might define intuition as that power of the mind by which we build the great theories and fit phenomena into a plan designed along the lines of unifying principles. To be more exact, the mind creates a world of its own. This world is conditioned by what we call the outside world, but in many respects we are free to make it what we please, just as the architect is free to create his building although his material limits him. However, we endeavor to create this world with the maximum simplicity, mainly because simplicity implies harmony, that is, beauty. We are not satisfied with what William James called the "blooming confusion of consciousness" but we construct a replica of this consciousness which is simpler. Of two ways we can construct the replica, we choose the simpler. Thus we choose Euclidean geometry instead of Lobatchevskian, on account of its simplicity, although either might be applied to the world of phenomena. We choose to say the earth rotates on its axis, for that makes astronomy possible. This replica must have a plan, a design, a symmetry, a coherence. Intuition is the perception of this idealized structure. It is akin to the dream of the artist, or the vision of the prophet. Indeed the eminent literary critic, Émile Faguet, calls Poincaré a poet. Was it not Sylvester and Kronecker who said that mathematics was essentially poetry! That was as far as they ever got in defining it. In his address on "Analysis and Physics," Poincaré says:

> Mathematics has a triple end. It must furnish an instrument for the study of nature. But that is not all, it has a philosophic end; and, I dare to say it, an esthetic end; . . . these two ends [physical and esthetic] are inseparable, and the best way to attain the one is to keep the other in view.

The mathematician does not build in stone, nor paint on canvas, nor construct a symphony, though his harmonies are in and through all these; his medium is more ethereal; but is his creation therefore the less beautiful?

Since the intuition is necessary, the first problem of education becomes the conservation and development of this power. Poincaré points out that in mathematics, for example, we should not begin with general definitions and laws, nor with rigorous logic in the proofs of

the theorems. Thus he recommends that in the special mathematics of the secondary school and in the first year of the *Ecole Polytechnique,* there should not be introduced the notion of functions with no derivatives. At most we should content ourselves with saying "there are such, but we are not concerned with them now." When integrals are first spoken of, they should be defined as areas, and the rigorous definition should be given later, after the student has found many integrals. He says:[10]

> The chief end of mathematical instruction is to develop certain powers of the mind, and among these the intuition is not the least precious. By it the mathematical world comes in contact with the real world, and even if pure mathematics could do without it, it would always be necessary to turn to it to bridge the gulf between symbol and reality. The practician will always need it, and for one mathematician there are a hundred practicians. However, for the mathematician himself the power is necessary, for while we demonstrate by logic, we create by intuition; and we have more to do than to criticize others' theorems, we must invent new ones, this art, intuition teaches us.

We turn finally to the research student. How is he to bring the intuition to bear on his problem effectively? If creative work is to be hoped for only through this agency, how do we set it to work? This question Poincaré answers in his analysis of his creation of the fuchsian functions. He holds that the intuition does its work unconsciously. We can not use the term "subconsciously," for he had a repugnance to the doctrine of the superiority of the subliminal self. He points out that our unconscious activity forms large numbers of mental combinations, as an architect, we will say, makes many trial sketches, and of these combinations some are brought into consciousness. These are selected, he believes, by their appeal to the sentiment of beauty, the intellectual esthetic sense of the fitness of things, the unity of ideas, just as the architect from his haphazard sketches selects the right one finally by its appeal to his sense of beauty. Poincaré admits that this explanation of the facts is a hypothesis, but he finds many things to confirm it. One is the fact that the theorems thus suggested in mathematical creation are not always true, yet their elegance, if they were true, has opened the door of consciousness to them. It was Sylvester who used to declare:

> Gentlemen, I am certain my conclusion is correct. I will wager a hundred pounds to one on it; yes, I will wager my life on it.

But it often turned out the next day that it was not true. However, it led eventually to things that were true. The direct conclusion from Poincaré's hypothesis would be that we must conserve and develop the esthetic sense of our field, whether mathematics, physics, chemistry, or what not. And we may well pause to consider whether the young

[10] *L'Enseignement Math.*, 1899, p. 157.

investigator should not include some course in design in his work, in painting, architecture, music, poetry or sculpture. Courses in the appreciation of art, rather than the criticism of art, might also be very serviceable indirectly. The constructive philosophers, like Plato or Bergson, might furnish valuable indirect training. Reading that leads to an appreciation of the beauty and sublimity of the universe is of the same value. In any case whatever would intensify the esthetic sensitiveness would be worth while.

When the intuition does not favor us, the golden butterfly fails to emerge from its chrysalis, what is to be done? Here is his answer for whom time did not count, taken from one of his most recent papers.[11] There is a note of pathos in it as well as a hint of premonition. He presents some incomplete results of a new and very important theorem in geometrical transformation, which he is convinced is true, yet the proof of it encounters great difficulties. Every particular case he has been able to settle is favorable to the theorem. After explaining why he is publishing an incomplete paper for the first time, he says:

> It would seem that in this situation I should abstain from all publication so long as I have not solved the problem, but after fruitless efforts for many months it seems to me wisest to let the whole problem ripen during several years. That would indeed be well, were I sure of some day being able to take it up again, but at my age I can not go bail for this. On the other hand, the importance of the subject is great . . . and the totality of results so far obtained is too considerable for me to resign myself to definitively allowing them to become unfruitful. I may hope that the mathematicians who interest themselves in the problem and who will be more fortunate than I without doubt will find some means to resolve it.

Again, Poincaré points out that these flashes from below the horizon of consciousness must be preceded by periods of prolonged attentive work. It is like setting Pegasus to plowing corn, but this conscious effort is necessary. This discouraging wandering over the hills and rocks, examining the promising paths and the fragments that point to a nearby mine, day after day, is indispensable to success. It is the weary search over the face of the mountain and the driving of many fruitless drifts that eventually lead the prospector to his mine of gold. On this kind of drudgery Poincaré spent two periods of two hours each daily. The unconscious action of his mind did the rest of his work.

Neither does the discovery of the mine develop it. After the unconscious power has led us to our eldorado, it has done all it can. The deductions, the demonstrations, the applications, must be carried out at the expense of prolonged effort again. The intuition can not do this kind of work. Its region is the nebulous part of thought where the mental ions unite, dissolve, and whirl away,—or we may say that

[11] *Rend. Circ. Mat. Palermo,* 33 (1912), p. 375.

it is found where the breakers surge against the shores of the unknown. But in the consciousness, the stable, the crystallized, the permanent combinations are formed; the new world is organized, surveyed, mapped, and the frontier is widened. Here everything proceeds under hard supervision.

Finally, the research student, the investigator, must have a burning love for the search for truth, as well as for the truth itself. And when in his somber moods he asks, what does it signify in the end? he finds the answer at the close of Poincaré's "Value of Science." He expresses the significance of science in these clear terms:

> Civilizations are measured only by their science and their art. Some persons are surprised at the formula: science for science's sake; yet it is quite as good as life for life's sake, if life is only misery; and even as happiness for happiness' sake, if one does not place all pleasures on the same level, if one does not admit that the end of civilization is to furnish more alcohol to people who like to drink.
>
> Every action must have an aim. We have to suffer, we have to work, we have to pay for our seat at the show, but it is in order that we may see, or at least that others may sometimes see.
>
> What is not thought is nought; since we can think only thoughts, and every word we use in talking about things stands for a thought, to assert there is anything else than thought is a senseless affirmation.
>
> Meanwhile—a strange contradiction for those who believe in time—geologic history teaches that life is only an episode between two eternities of death; and even in this episode conscious thought has endured and will endure but a moment. Thought is but a flash in the midst of a long night.
>
> Yet this flash indeed is everything.

A CHRONICLE OF THE TRIBE OF CORN[1]

By Professor EDWARD M. EAST

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ALEXANDRE DUMAS maintained that he weaved more history into his romances than the contemporary chroniclers did into their histories. Perhaps he did. At least the reader may lose himself in the marvelously interesting fancies of the great Frenchman, and if he gleans some points of fact they are gratuitous—features for which he has not paid. But when he finds that his cherished enmity toward Aaron Burr is founded on the fictions of political opponents, that the reformation was largely politics and not ethics, he feels in much the frame of mind as when in earlier days he was robbed of his belief in Saint Nicolas.

These statements are not intended as a libel on the political historian. They serve only to defend the title of this article. The modern historian depends, first upon the records of writers contemporary with the epoch under consideration, second, upon the corroboration or refutation of these records by circumstantial evidence. The biological historian uses precisely the same method. His contemporary records are the records set down by the plants or animals themselves—autobiographies, as it were. He has this advantage over the transcriber of written records, however, the plant autobiographies are true. There is no boasting, no glossing of faults, no exaggeration. The transcriber may misinterpret the record, but this is not the fault of the record. He has but to read it aright. The written record, on the other hand, may be false at the outset.

The story of the birth and evolution of maize, the plant at the basis of our national prosperity, is of interest not only to agriculturists and botanists but to historians and philosophers, for it is one of the crops whose cultivation is linked with the beginnings of civilization. It has taken some years to fit the puzzle together, but now the gaps are but few. Of course the proofs are not absolute. No proof is. But it may be left to the judgment of the reader whether the case is beyond the reasonable doubt of the lawyer. At least, it is typical of the reasoning

[1] An endeavor to trace the exact path of the evolution of maize is beset with more difficulties than are indicated here. I agree with many of the conclusions of both Montgomery and Collins, whose excellent researches have given us a remarkable insight into the probable phylogenetic history of maize. I have endeavored to present in this paper only the probable way in which certain important jumps occurred, facts that might be supposed to be of more popular interest than a strictly botanical discussion.

FIG. 1. A TYPICAL MAIZE PLANT AS DESCRIBED BY THE BOTANISTS. (After Bonafous.)

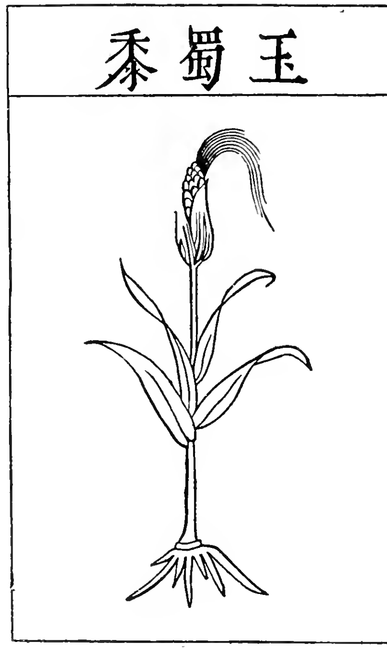

FIG. 2. A REPRODUCTION OF THE CHINESE DRAWING UPON WHICH RESTED THE ARGUMENT FOR ASIATIC ORIGIN OF MAIZE. (After Bonafous.)

of the botanical historian and has been carried further than that of any other plant that has been cultivated since before recorded time and of which the wild prototype is unknown.

The clues upon which the botanical detective works are many, and it is only by dovetailing numerous facts that the probability of a correct conclusion is increased until it is beyond question. That criminal detectives can establish a reasonable proof by circumstantial evidence was shown long ago by Poe. Mathematics does not recognize a series of coincidences. Coincidences do occur but not in series. If a series of facts point to the same conclusion, the probability that that conclusion is correct increases by multiplication, not by addition. If the probability that one throws heads with a coin is one half, the probability that he throws a pair of heads with two coins is one half times one half, or one quarter, not one half plus one half which would be a certainty. Thus the fictitious reasoners of Poe and Doyle have argued that if a series of independent circumstances point in a single direction, that direction is the proper one. If certain facts seem to be outstanding, they must be looked to, for their fallacies will sooner or later come to light. The same is true in botanical history as the following incident shows:

The sagas of Iceland show unquestionably that some time about the year 1000 the Norsemen landed in North America. Where they landed has been a question. The sagas describe the natives they met, the Skrellings, as small and ugly, great of eye and broad of cheek. "And they came in skin canoes." The description fits only the Esquimaux. The sagas relate further, however, that the Norsemen found mösurr wood and self-sown wheat and that in the spring they filled their boats with "wine berries." Students of the sagas have taken the wineberries to be grapes, the self-sown wheat to be wild rice and the mösurr wood to be maple. There were discrepancies here. The ethnologists say the Esquimaux have not wandered south, and the botanists find that the grape and the wild-rice do not grow in the northeast. It may also be pointed out that grapes are not gathered in the spring even in the most flourishing circumstances.

Some have ridiculed the sagas, some have brought the Esquimaux as far south as Boston, others have turned the Skrellings into Indians in spite of their description. It remained for a botanist, Professor M. L. Fernald, to show that the mösurr wood is birch, that the wild wheat is the Strand wheat (*Elymus arenarius*) a plant familiar to the Icelanders, and that the wineberry is either the mountain cranberry that is in its prime in the spring or one of the wild currants, both plants being known to the Norsemen as vínber or wine berries. The plentiful occurrence of these species north of the St. Lawrence River straightens out all the inconsistencies and makes the geography, ethnology and biology of the old sagas perfectly plausible.

This short illustration typifies the method of the botanical historian, though perhaps the details of his work had best be explained. Foremost in the significance of its evidence is the geographical distribution of the wild plant and its subvarieties. From this knowledge one may sometimes locate the point of origin with surprising definiteness. But often an important cultivated species has no known progenitor in the wild. This lack of information is unfortunate for the investigator, but not prohibitive of results. It makes the problem only that much more interesting. The next point of attack is to discover the distribution of the wild species nearest related by their structure and characteristics to the material under investigation. The fact that an organic evolution has occurred is the master key that unlocks many problems. Classification along natural lines wás made possible by establishing the fact of evolution. The relatives of plants are hall-marked in a manner not often mistakable, and if the general family group is not too widely distributed, the problem may be considered as fairly well along.

If there are no near relatives extant, if the plant is the last leaf upon the family tree, one must turn to the evidence of the plant itself. By this I mean he must study the inheritance of the various characters

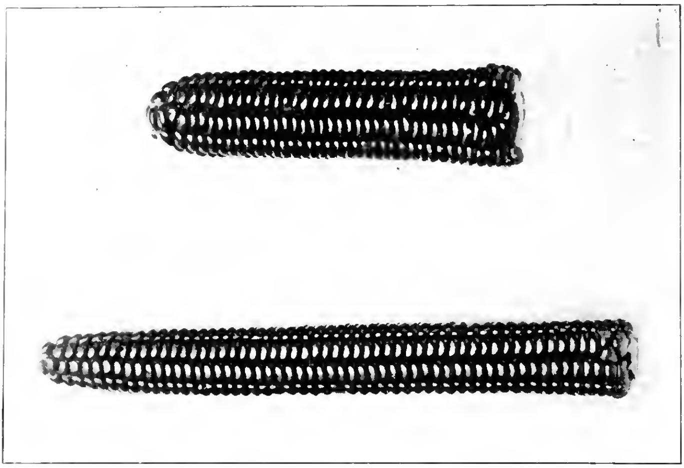

Fig. 3. An Ancient Indian Flint Type Above, with its Modern Successor Below.

by which its varieties are differentiated and endeavor to find out how the features peculiar to it have originated. He may then be able logically to connect it with very distant relatives.

Now to turn to the collateral evidence. Collateral evidence on distribution and relationship is furnished by paleontology. Such data are really direct and important when fossil remains occur in sufficient quantities, but this is not often the case. It is usually fragmentary and can be classed with that of archeology. Neither archeology nor history furnishes certain proof of plant origin, however, as we shall see. Their evidence must simply be given the weight it deserves when considered with other facts. Lastly, philology furnishes indications as to the history of a species, for common names of cultivated plants are well preserved in the languages of the people who have used them. But, like other evidence, it must be accepted with caution. The cashew is called by the French *pomme de Mahogani*, which is all right except that it is not an apple and has nothing to do with mahogany. This shows how much worse a compound name is than a simple name, since with a simple name there can be but one error.

We shall endeavor to construct our history and evolution of maize along these lines, though not keeping the same order.

Maize has not been found in the wild state, although it is such a remarkable plant it seems improbable that with our present knowledge of plant distribution it should remain undiscovered if in existence. This fact has made the problem of its nativity very difficult, even though Americans have been satisfied of its new-world origin for some time. Competent critics have skillfully argued old-world origin, and from the strictly historical point of view there was earlier much to be

said in their favor. The word maize (mays) itself is strictly American, but this name has been in use only since adopted by Matthiole in 1570. In modern European languages the common name has been one purporting to show eastern origin, in English Indian corn, in French *blé de Turquie* or Turkish wheat. Since maize is not wheat, it might almost be concluded it was not Turkish. The trouble was, one could not prove it. As a matter of fact, such names only show the tendency of a people simply to indicate the foreign origin of an introduced article, as when the French gave the name coq d'Inde or Indian cock to the American turkey. According to De Candolle maize was called Roman corn in Lorraine and Vosges, Sicilian corn in Tuscany, Indian corn in Sicily and Spanish corn in the Pyrenées. The Turks call it Egyptian corn and the Egyptians, Syrian *dourra*, which prove it to be neither Egyptian nor Syrian.

It has been generally agreed by historians that there was no Hebrew or Sanskrit word for maize and that there was no Egyptian representation of the plant. It is true, Rifaud found an ear of maize in a tomb at Thebes, but this was the work of a modern impostor, for if maize had been a crop of ancient Egypt, pictures of it would have been as plentiful as they are of other Egyptian plants. The plant certainly was not known in Europe in early times, but the question ever arose whether or not it could have been introduced from the East during the Middle Ages. Bonafous, who was the foremost writer on the subject in the early nineteenth century, took this view and was responsible for long-continued doubt on the subject. The principal evidence on the question was that obtained from a charter drawn up between two crusaders in 1204, according to which seeds thought to be maize and brought from Anatolia were presented to the town of Incisa. Historians of the crusades made much of this charter, although botanists thought from

FIG. 4. A GIANT FLOUR CORN FROM PERU COMPARED WITH A DWARF POP CORN FROM THE UNITED STATES.

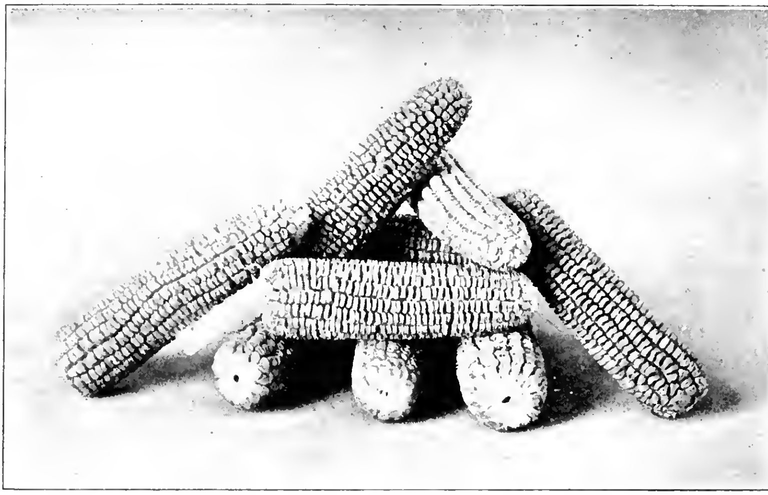

FIG. 5. A PRIZE-WINNING SWEET CORN.

their description that the seeds might be sorghum instead of maize. The absurdity of relying on such isolated clues came out with the discovery that the whole charter of Incisa was a modern fabrication.

The only other evidence of eastern origin that there has been any trouble in demolishing is a picture of an ear of maize together with its ideograph in a Chinese book written some time between 1578 and 1597. Since the Portugese came to China in 1516 and to Java 20 years earlier, it is plain this is not good evidence of Chinese origin. During the half-century between this date and the date of the article, nothing could be more probable than Portugese introduction of maize into China. Furthermore, the fullness of early Chinese records is such that they would hardly have remained silent on an important agricultural crop until 1578.

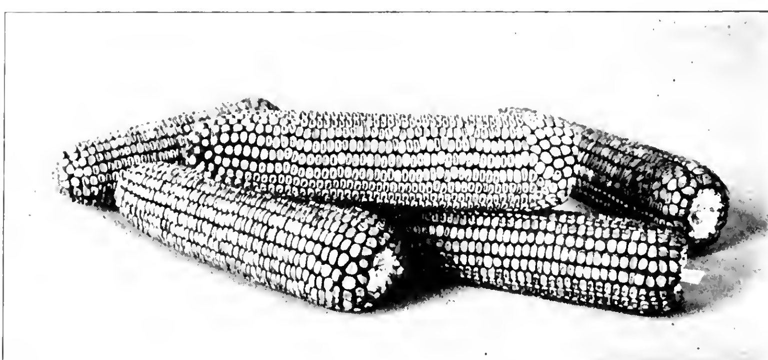

FIG. 6. A "CHAMPION" SAMPLE OF OUR GREATEST ECONOMIC TREASURE, THE IMPROVED DENT CORN.

This dearth of early records of the plant in the old world shows convincingly the American origin of the plant, for after the discovery of America its cultivation became rapidly diffused, a proof that if indigenous to Asia it would have been important agriculturally for centuries.

On the other hand, no one has ever questioned the fact that maize was widely cultivated in America at the time the country was discovered by Europeans. It was the staple crop in both continents and had names in all the native languages. Its antiquity and importance are evidenced by its prominence in the religious rites of the people. The North American burial mounds, the tombs of the Incas and the temples of Mexico were made depositories of the seeds just as the tombs and temples of Egypt treasured wheat and barley. These facts do not indicate antiquity in cultivation equal to that of Egypt, however, for the

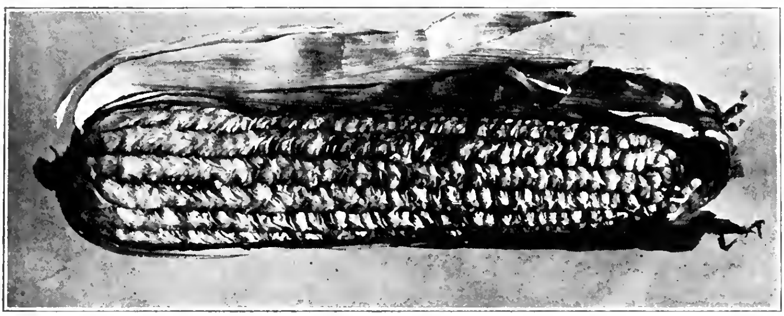

FIG. 7. AN EAR OF THE MEXICAN PODDED CORN (*Zea mays tunicata*).

civilization of the Peruvians and Mexicans is known to be of a much later era. At the same time, one may assume a history much longer than that indicated by these data for two reasons: from its wide distribution and numerous ancient varieties, and from Darwin's discovery of its seeds mixed with shells buried in soil along the Peruvian shore that had become raised by natural action 85 feet above sea level.

The American origin of maize being assured, interest in our problem narrows. The Americas are large. To what particular part was the plant indigenous? First let me say that it is a peculiar fact that the vast territory now known as the United States produced no cultivated plants of first importance. Excluding the Jerusalem artichoke, some comparatively unimportant berries and some relatives of the apple, our country gave man no agricultural treasures. It merely accepted with thanks the lavish generosity of the tropics. As far as maize is concerned, the physiology of the plant itself corroborates this statement. It germinates and grows best in hot climates. We must look for the home of maize, therefore, in the plains or plateaus of tropical North

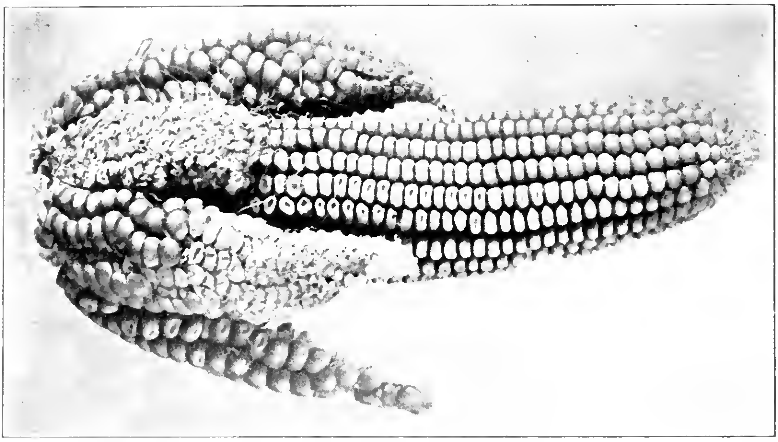

FIG. 8. A REVERSION TO THE ANCIENT BRANCHED EAR TYPE.

or South America—the plains because annuals do not develop in forested regions. Under the circumstances, our search need only be the less troublesome absentia search in botanical records, since the regions have been combed by botanical explorers for three hundred years. The result as far as maize is concerned was *nil*. Perhaps though the word nothing is too exclusive. First cousins of our interesting family were discovered in Mexico and Guatemala, the plant called teosinte; and experimental evidence indicates a sufficiently near relation to justify these regions as the original home of the emigrant. This evidence, which gives us a picture of the original plant, is now to be considered.

Maize varieties differing slightly from each other are now numbered by the hundred. Of these, five or six differ by very distinct characters and have come to be thought of as subspecies. Those known as dent, flint, pop, sweet and flour corns are familiar to every one. One known as *Curagua* with toothed leaf edges, one with very hairy leaves known as *hirta* and one in which each seed is covered with husks or glumes known as *tunicata* are not so common. These varieties are our heritage from the aboriginal inhabitants, for each was known and cultivated some-

FIG. 9. A COMMON REVERSION HAVING SEEDS ON THE TASSEL.

where on the continent before the arrival of Europeans. They are considered by botanists as one species. The wild relative teosinte has been thought to be not only a distinct species but a member of a different genus. There is good evidence, however, that there is not a much greater difference between teosinte and the maize nearest like it than there is between a number of the most distinct maize varieties. These facts make it reasonable to suppose that both types arose from a common ancestor slightly different from each.

Teosinte and maize belong to the tribe Maydeæ, a division of the Gramineæ or true grasses. Our final problem is to connect the steps in the evolution of maize that distinguish it from the more typical grasses and if possible to picture the restored original form. The data from which one can do this come from observations of thousands of crosses between the different maize varieties.

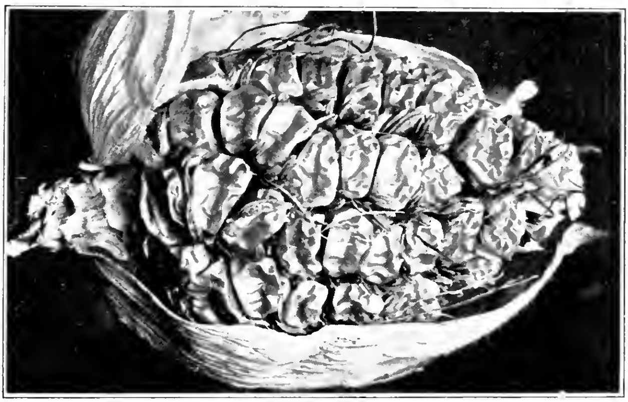

FIG. 10. A RARE REVERSION TO PERFECT FLOWERS.
Note the stamens around the seeds.

Sweet corn is probably the most recent type. Sweet corns are simply dent, flint, pop and floury types that have lost the ability to mature starch grains. This is proved by crossing it with starchy kinds. For example, dent corns crossed with certain sweet corns produce flint types in the second hybrid generation. Starchiness is put into the hybrid by the dent variety and the latent flintiness of the sweet variety appears.

In the same way crossing indicates that as the pop or poplike varieties increased in size by numerous slight variations, the flint, the dent, and the floury kinds were produced through the correlation between the structure of the seeds and their size. This brings us back to a many-branched pop-like variety, examples of which are common enough to-day.

Most maize varieties have naked seeds, a feature unlike other grasses including teosinte. The remaining members of the family have

Fig. 11. Teosinte. (Photo by L. H. Smith.)

the seeds protected from animal marauders by husks or glumes. This is again a simplification caused by the loss of a character, as is proved by crossing the ordinary maize varieties with the variety *tunicata* in which the character still remains. This gives us a grass-like corn with each seed covered—a plant in many ways like teosinte. It still differs from it by but one important and several unimportant characters, and the difference can not be particularly significant, for maize and teosinte cross freely and give fertile hybrids.

The difference is this: The female or pistillate spike of maize, the part which we call the ear, consists apparently of several two-rowed

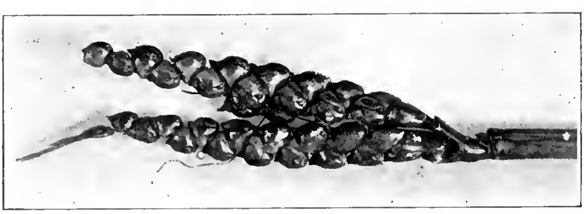

Fig. 12. A Teosinte-Maize Hybrid showing the Dominance of the Teosinte Characters. (Photo by Webber.)

spikelets grown together; the same part in teosinte consists of bundles of distinct two-rowed spikelets with jointed axes. It takes two steps to bring maize to something like this condition. Ordinary maize varieties often produce individuals that have ears branched in much the same manner as the tassel or male spike. This is probably a reversion toward a former type. At least, pure varieties of this kind can be isolated. Furthermore it can be shown by crossing that the branched condition is due to a single hereditary character that has been lost by the cultivated kinds. The other step is the increase in number of rows, giving us the fine ears with from 18 to 24 rows that take the prizes in the agricultural shows. This feature is probably not due to the growing together of the spikelets. It is much more likely that increased number of parts came about through progressive variations, much as the increase of petals has brought the horticulturist so many double flowers. This type of variation is very common and still continues in maize, for the prize ears of the exhibitions contain many more rows than the more ancient little flints that were grown by the east coast red men.

The fact that but two essential variations, kinds that continue to occur, separate teosinte[2] from the maize nearest like it, combined with the fact that the two are fertile in crosses lead me to believe that the two plants are simply diverse types of the same polymorphic aggregation, although they may be called species if one desires.

Perhaps we should stop here and not follow the path of speculation to its uttermost limit; still there are two more backward steps indicated by studying the cultivated plant. The plant is monœcious; that is, the male organs and the female organs are borne in separate flowers, though both are found on the same plant. This condition is not uncommon among the grasses although it is not the primitive condition. The unique fact is that the female flowers that form the ears are borne on short branches in the axils of the leaves of the maize stalk, while the male flowers are borne in a terminal spike, the tassel. This method of flowering is not so peculiar if the ear branch is examined. The husks that surround the ear are merely the leaves of the lateral branch upon which the ear is borne as a terminal spike. The lateral branch has simply shortened. It is telescoped together until the distance between the nodes is sometimes not more than an eighth of an inch. It seems just to conclude from the number of these internodes that the ear branch was at one time as long as that portion of the main stalk above the ear, that the flower spikes of the ancestral plant were once more or less level topped, bringing them into a horizontal plane. What caused the change

[2] There are a large number of characters of less importance separating maize and teosinte that show that the two plants have developed along different lines after their separation from an ancestor more like both.

we do not know, but if the plants were already monœcious before the change, and such a variation occurred, it would have been likely to have continued to exist in competition with the parent form on account of the greater chance for perfect fertilization of the silks.

The last step in our history is to make ancestral maize a perfect flowered species; that is, a form in which each flower has both male and female organs. There is no question but that this was once the case. We know it by the characters possessed by the more ancient wild grasses and by the ease with which the plant reverts to the former condition. No one has isolated a race that breeds true to the older type, but every one who has raised corn has seen hundreds of tassels containing little seeds. It would seem that kindly external conditions alone are sufficient to bring back to the corn the memory of its old habit. When moisture is plentiful and the soil fertile, one can see these freaks by the hundreds in almost every field. The production of male flowers or their essential parts, the stamens, on the ears is much more rare, but it does occur.

Our history is complete. We can picture to ourselves the wild promaize growing on the plateaus of Mexico and Central America thousands of years ago. A towering prince of grasses it was, bearing its tiny seeds on loose spikes at the ends of the branches. Conditions changed. The perfect flowers separated into two kinds, bearing organs of the different sexes. A type with shortened side branches appeared, giving the seeds greater protection from feathered and furry enemies. This was probably the grain that some wise man among the forerunners of the Toltecs discovered and made the foundation of American agriculture. From that time forth cultivation made possible the selection of variations that would not have survived in the wild. Variation must have been plentiful, and our aboriginal corn breeders less foolish in agriculture than they were in commerce, as is demonstrated by the numerous varieties improved by long selection presented to the white man in return for a few paltry beads of colored glass.

THE UTILIZATION OF THE NITROGEN OF THE AIR

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A GERMAN geographer has estimated that the world contains 1,700 million people, and that they are increasing at the rate of twelve million a year. During each succeeding decade, therefore, provision must be made for feeding a new population greater than the present population of the United States. This demands an enormous, steadily growing increase in the world's output of agricultural products. How to provide for this increase is one of the largest material problems that confronts our generation and the generations to come. Many factors must contribute to its solution. New land must be brought under cultivation by a wider distribution of population, by increased facilities of transportation, by better utilization of the available water-supply through storage and irrigation. A larger yield per acre must be secured by improvement of the varieties of food-yielding plants through biological selection and breeding, through the adoption of more economical methods of farming, and especially through increasing and maintaining the fertility of the land by the scientific use of fertilizers in adequate amount.

This last aspect of the problem is the one with which this article is concerned. It is a vital part of the food problem, one which can not be eliminated by advances in any of the other directions just referred to: for plants can not live on water and air alone. They consist, to be sure, in largest proportion of compounds of carbon, hydrogen and oxygen; and they have the marvelous power of producing these compounds under the influence of sunlight from the carbon dioxide of the air and the water of the soil. But they contain also as essential constituents certain other elements, especially nitrogen, phosphorus and potassium, which they can not obtain from the air, which they must therefore extract from the soil. These elements are, however, present only in small quantity even in virgin soil; and they soon become exhausted through the harvesting of successive crops. It is therefore necessary, in the long run, to return to the soil the quantities of nitrogen, phosphorus and potassium that are contained in the vegetable products taken from it.

The sources from which we can obtain these three plant-foods cheaply and abundantly is so large a question that only one of them, nitrogen, will be here considered. Of the three this is by far the most expensive—by far the most difficult to obtain in sufficient quantity at low cost.

Before discussing the present and prospective sources of supply of useful compounds of this element, it should be mentioned that, though the consumption of these compounds in fertilizers exceeds all other uses of them, yet enormous quantities are required in other industries. Thus, the powerful modern explosives which have made practicable great engineering works, like the Panama Canal and the Hudson River tunnels, are all nitrogen compounds—made by the action of nitric acid on glycerin, cotton, or some other material. Most of the so-called coal-tar products, the artificial dyestuffs, drugs and perfumes, are also prepared from the substances distilled out of the tar by first treating these substances with nitric acid. Ammonia, too, a compound of nitrogen with hydrogen, is used in large quantity in refrigerating plants and in various chemical industries.

Up to a few years ago, there were only two important commercial sources of nitrogen-compounds—the great natural deposits of sodium nitrate (the so-called Chili saltpeter) in Chili, Peru and Bolivia; and the crude ammonium sulfate obtained in the manufacture of gas and coke from coal. But the saltpeter deposits will, at the present rate of exploitation, become exhausted within a period variously estimated at from 30 to 100 years; and, in the meantime, owing to increased cost of production, the price of the saltpeter is steadily rising, thus restricting its availability as a fertilizer. The ammonia produced in gas and coke works is only a by-product; and the quantity of it can not of course be increased beyond that corresponding to the demand for the main products, gas and coke. The total quantity of ammonia thus produced is in fact entirely insufficient to furnish the nitrogen used in fertilizers; and by far the larger proportion of commercial nitrogen is still derived from the saltpeter deposits of South America.

The nitrogen from these sources costs to-day in American or European markets not far from 15 cents a pound—a price which is causing a nitrogen famine among the crops of the world; for the cost is too high to admit of spreading it in adequate quantity over the millions of acres of land under cultivation. This condition of things offers a challenge to the scientific investigator. For, though nitrogen is one of the commonest elements, forming as it does, four fifths of our atmosphere, yet we are drawing nearly all our nitrogen from South American mines or from gas works and are paying fifteen cents a pound to get it in a form available for plant life.

It might seem as if the problem of converting the nitrogen of the air into compounds that can be assimilated by plants was essentially a chemical one; but recent discoveries have opened also to the biologist a great field of investigation in this direction. For it has been found that, although the higher plants can not utilize directly the nitrogen of the atmosphere, there are certain common kinds of bacteria, which

make their homes on the roots of leguminous plants, such as the pea, bean and clover, which have the power of absorbing nitrogen from the air and of converting it within the roots of the plant into organic nitrogen compounds.

This discovery explains for the first time the fact long known to farmers that the richness of the soil can be increased by rotation of crops—a fact so extraordinary, till its explanation was understood, that one might well have wondered whether it was not one of the fallacious traditions which are so common among farmers and sailors. This increased fertility is now readily accounted for as follows. Suppose that a crop of wheat is first grown on a piece of land, and that thereby the nitrogen compounds in the soil are largely consumed in producing the nitrogen compounds contained in the grain. Suppose now that the next year the same land is planted with clover. As it grows, the bacteria referred to develop upon its roots, absorb nitrogen from the air, and store up in the roots an abundant supply of nitrogenous compounds. After the clover crop is harvested, these roots decay in the soil, yield up to it their nitrogen-content, which becomes available for the nourishment of a new wheat crop during the following year.

An interesting illustration of these considerations has been furnished within recent years by the vegetation of the island of Krakatoa. It will be remembered that this island was overwhelmed in the year 1883 by an eruption of its volcano, which destroyed all vegetation and buried the original soil beneath a thick layer of volcanic ashes. It might have been expected that this new soil of ashes, which was of course free from all nitrogenous organic matter, would not be able to support plant life; yet the island soon became covered with an abundant growth. This vegetation was found, however, to be of an unusual character, in that it consisted very largely of leguminous plants—that is, of those plants which, with the aid of bacteria, can take their nitrogen directly from the air.

These facts suggest that the problem of supplying plants with the nitrogen needed by them may ultimately be solved most simply and directly by the biologist. For through further study of the conditions determining the activities of different species of nitrogen-absorbing bacteria, considered in relation to the kind of crop, the character of the soil and other agricultural conditions, it may prove practicable, by inoculating the soil with the proper kind of bacteria and by treating it in such ways as will best regulate bacterial growth, to secure all the needed nitrogen from the air. Already, government agricultural stations are furnishing pure cultures of nitrogen-absorbing bacteria which have a limited value in the case of certain soils.

Until such a perfect solution of the problem can be worked out by

the biologist, we shall, however, be dependent on nitrogenous fertilizers; and one of the great tasks of the chemist is to cheapen such fertilizers by obtaining the nitrogen contained in them directly from the air. During the last ten years great progress has been made in this direction; and it remains to describe briefly, without entering into technical details, the general lines along which this problem has been successfully attacked.

Two kinds of processes have been developed. One of these has the object of producing nitric acid, a compound of water with one of the oxides of nitrogen. The other kind of process has for its object the production of ammonia, a compound of nitrogen and hydrogen. For use in a fertilizer the nitric acid, which is a liquid, or the ammonia, which is a gas, must of course be converted into a solid salt. This is most cheaply done by neutralizing the nitric acid with lime or the ammonia with sulfuric acid, yielding calcium nitrate or ammonium sulfate, respectively. Whether the nitrate or the ammonium salt is made the constituent of the fertilizer makes little difference; for, though plants directly assimilate the nitrogen only in the form of nitrate, yet there are always present in soils the so-called nitrifying bacteria, whose function it is to convert ammonium compounds into nitrates.

Nitric acid is a compound whose constituents, nitrogen, oxygen and water, are present in unlimited quantities in the air. The raw materials are available free of cost. The problem is therefore only to make them combine under economic conditions. The difficulty arises from the fact that nitrogen is an extremely stable substance; so that, instead of tending to form compounds with oxygen, the nitrogen oxides tend rather to break down into their elements, nitrogen and oxygen. Thus, scientific investigations have shown that if a mixture of these two gases in the best proportions is exposed to a temperature of 1500° centigrade, that is, to a white heat, only one third of one per cent. unites to form nitric oxide, however long the mixture be heated. But these investigations have also shown that while most compounds decompose with rise of temperature, this one, nitric oxide, becomes more stable, the higher the temperature. Thus at 3000° five per cent. of the mixture of nitrogen and oxygen will unite to form nitric oxide. To get a fair yield of our product we must therefore expose air to an enormously high temperature. But this isn't all; for we must cool off the gas without causing the nitric oxide which has been formed to break up again into nitrogen and oxygen. To do this, we must call to our aid another chemical principle, which is this: although the quantity of a product finally formed in a chemical process sometimes increases and sometimes (as in this case) decreases with falling temperature, yet the rate at which that product forms or decomposes always decreases very rapidly as the temperature is lowered. We must,

therefore, expose the air to a very high temperature and then very suddenly cool it to a temperature so low that the nitrogen oxide already formed does not decompose at an appreciable rate.

These conditions have been practically realized in only one way—by causing an electric discharge, similar to that in an ordinary arc lamp, to take place in air. The temperature of the arc is enormously high, but the air just outside of it is comparatively cool; so that any nitrogen oxide formed at the boundaries of the arc mixes at once with the colder air and thus escapes decomposition. The excess of air containing the oxides of nitrogen is then passed into towers filled with quartz over which water is trickling, whereby nitric acid is formed.

It is not necessary to enter further into details; for these are the essential features of the commercial process for the manufacture of nitric acid which is now being carried out on a large scale at Notodden in Norway. Aside from the cost of installing and maintaining the electrical and absorbing apparatus, the only large expense involved in the process is the cost of power used in producing the electric discharge. The works must therefore be located where water-power is obtainable at the lowest possible cost; and Norway was naturally chosen as the seat of the industry in Europe. The saltpeter factories there are already utilizing 200,000 horse-power; and thousands of tons of their product have been shipped to this country, for use in fertilizing the fruit orchards of California and the sugar plantations of Hawaii.

Almost simultaneously with this process for the manufacture of nitrate there is being developed a process for the artificial production of ammonia, its competitor in the fertilizer field. The aim is to produce this compound also from its elementary constitutents, nitrogen and hydrogen. Nearly pure nitrogen can now be obtained cheaply from the air by a commercial process which up to twenty years ago had been carried out only on the smallest laboratory scale; namely, by liquefying air with the aid of a liquid-air machine, and then distilling the mixture of nitrogen and oxygen, much as a mixture of alcohol and water is distilled in the rectification of spirit. The nitrogen, having a much lower boiling-point, passes off first, yielding a gas containing less than half a per cent. of oxygen, which can readily be removed from it by chemical means. Pure hydrogen can be obtained cheaply by the decomposition of water in two or three different ways. The raw materials needed for the production of ammonia, although not costless like the air and water used in making nitric acid, are therefore obtainable at low cost; and the main problem again consists in finding a practical way of causing them to combine.

It is a curious fact that difficulties are met with here which are just the reverse of those encountered in the synthesis of nitric acid. Ammonia is a compound on which temperature has the opposite effect:

instead of forming in larger proportion as the temperature is raised, it forms in smaller proportion; thus, if a mixture of nitrogen and hydrogen be heated for a long time to 800° centigrade, only one hundredth of one per cent. of ammonia forms, while it can be calculated that at 400° one half of one per cent. of ammonia must finally result. We ought therefore to work at as low a temperature as possible; but we then meet the difficulty that the rate of combination becomes extremely slow. Thus, owing to the extreme inertness of nitrogen, no detectable quantity of ammonia is produced, even when nitrogen and hydrogen are heated together for several hours at 400°. When, however, it is known that a chemical change tends to take place in a certain direction and when the only difficulty is that it is going on too slowly, there is always a reasonable hope of overcoming this difficulty; for we know that chemical changes are often greatly accelerated by mere contact with suitable solid substances. Such substances are called catalyzers, and Professor Wilhelm Ostwald, one of Germany's distinguished scientists, predicted a dozen years ago that the great advances in the chemical industries within the next few decades would be made through the more extensive employment of catalytic processes. This prediction has found one of its many fulfilments in the commercial development of the method for the production of ammonia here under consideration. For after many years' investigation, certain metals have been found which cause a rapid combination of nitrogen and hydrogen even at comparatively low temperatures. The first metal that was found to have this power in a marked degree was osmium, a metal similar to platinum. As the total quantity of this element in our possession is estimated to be 200 pounds, and as it is valued at about $1,000 a pound, this discovery was hardly a practical one. Later it was found, however, that under special conditions some of the commoner metals, such as uranium, manganese, and even iron, when extremely pure, can be made to serve the purpose. Without entering into further details, it may be stated that a satisfactory yield of ammonia can be attained by carefully purifying the hydrogen and nitrogen gases, by highly compressing them (up to 50 or 100 atmospheres) and then passing the compressed gases slowly over one of these metals at 500–600°; and that a large factory for the manufacture of ammonia by this process is now being erected in Germany.

Certain other chemical processes for the fixation of atmospheric nitrogen, less direct than those already described, but nevertheless commercially practicable, have also been developed and put into operation within the past ten years. There is therefore little doubt that from these sources a large additional supply of nitrogen-compounds will soon be available and that their cost will be gradually lowered. To the vital problem of feeding the human race the chemist is therefore making an important contribution.

THE LABORATORY METHOD AND HIGH SCHOOL EFFICIENCY

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IT is a striking fact that for twenty years there has been *no increase in the percentage of pupils who complete a high school course.* In the period between 1900 and 1910, the number of pupils in public high schools in the United States has increased over 76 per cent. (from 519,251 to 915,061).[1] During this same period the number of high school teachers who teach these pupils has increased over 100 per cent. (from 20,372 to 41,667). The number and value of high school properties has increased proportionately during this period, including improvement in the quality and quantity of facilities for work in libraries, laboratories, gymnasia, etc. But for twenty years, approximately twelve per cent. of the enrollment of the high schools has been graduated. Regardless of the increase in facilities, and of an increase in teaching force, which is one third greater than the increase in the number of pupils, and of an assumed increase in the relative efficiency of this teaching force, and regardless of the increased public belief in secondary education, there has been no increase in twenty years in the percentage of high school pupils that take a full high school course. The fact that they begin the work indicates clearly that some one in control regards it as worth while for some reason for these pupils to engage upon the work of the secondary schools, though they may at the outset expect to do but one or a few years of the work. But the fact that approximately 88 per cent. do not complete a course indicates that most of those who thought it worth while to enter the high school, for some or many reasons do not find it possible or perhaps not worth while to follow out the course, even if at the outset they intend doing so.

Failure to carry school work is one prominent factor in the elimination of pupils from school, though doubtless the content of the curriculum, and social and economic conditions may often be determining or contributing factors. In one large high school 432 pupils entered the freshmen class in the autumn of 1909. Of these 432, 338 left school before completing the third semester, thus leaving 94 of the original 432 in school. Of those who left, 124 made no passing credit in the school and 121 others failed to receive passing credits in 43 per cent. of the subjects which they took. The remaining 93 pupils who left school made average grades above 80 per cent. (75 being the passing grade in

[1] Ann. Rep. U. S. Com. of Ed., 1911, p. 9.

this school) though the pupils failed to secure credit in 22 per cent. of their subjects. There were, therefore, 245 of the 338 pupils who had a percentage of failure from nearly half to all of their subjects, and 93 pupils who failed in 22 per cent. of their work. The 94 pupils who remained in school failed to receive credit in slightly less than 5 per cent. of their subjects.

It seems possible that this case is more striking than would usually appear from such investigations since the problems associated with this particular school may be peculiarly difficult.

In a careful study made by Mr. G. R. Johnson, of St. Louis, and covering records from twelve high schools with a total number of 18,926 pupils, he finds that approximately 90 per cent. of those pupils who were failing in their work left school, while but ten per cent. of those who were making 90 per cent. or better in their work left school. This percentage of those who failed and left school remains almost constant throughout the four years, with the exception that in the Chicago and Kansas City schools rather a larger percentage of the failures drop out in the earlier years than in the later years, while in the smaller schools the percentage of dropping out of those who fail remains about the same throughout the whole high school course.

Doubtless the compulsory attendance law and the sixteen-year labor law often are factors in continuing for a time the attendance of pupils who do poorly, and that with the close of the sixteenth year economic and social necessity takes many pupils out of school. But we must note the fact that the percentage of failures who leave school remains almost the same for all the years of the high school. Possibly the termination of the period when pupils *must* attend school may operate to relieve those who are failing, from the necessity of further attendance in an institution in which they do not "make good."

School methods (of dealing day by day with the series of topics that make up a given study) *are often contributing causes to the failures which lead pupils to leave school.*

The present situation is interesting. In the elementary schools from which these pupils have come to the high school, the school day runs from 8:30 or 9:00 o'clock to 3:30 or 4:00 o'clock and the greater part of all study is done during school hours, under direct or indirect supervision of the teacher. The teacher is present to correct any misunderstandings in assignments, to give a directing question or suggestion, or to quicken the endeavor, when such is needed. The work of one year is fairly well connected with that of the preceding years and partially new and partially old ground is covered each year. In the high school, particularly, in the first year, the subjects of study are largely or wholly new, often so new as to constitute fields quite unknown to the pupils. Even when some of the subjects are not new, we

have a larger change than occurred between any two elementary grades. Pupils in a given subject go to the special room of the teacher for their recitations, recite and receive their assignment and then go to another class room for another subject, or return to their assembly room or to their homes with their assigned work for the next day. The teacher in the elementary school ordinarily meets the pupils of a given grade for most or all of their work, and knows them as they appear in all their work. In high school each teacher is especially interested in one or a few subjects and this one or few are the only ones in which the teacher knows his pupils. In the elementary schools the teacher usually stands as representative of one *grade of pupils.* In the high school the teacher usually stands as representative of *a subject.*

Not only does the first-year high school student encounter a new content of subject matter, but usually a new kind of school day. Many high schools begin work at 8:30 or 9:00 o'clock and close at 1:00 or 1:30 or 2:00 o'clock. In many high schools all of the hours in school are occupied in recitation or laboratory work, all individual study or assignments being done away from school.

The conditions for home study present all the possible variations, but most home study must be done under discursive influences—a little study, a little conversation about irrelevant matter, an intermittent discontinuance for small household duties, a prolonged intermission for recreation, with the half-consciousness of wrong-doing because of unfinished and overhanging lessons, even interrupted sleep because of a number of unfinished tasks, a final effort to secure categorically such facts regarding the assignment as are essential to enable the pupil to meet the teacher, a consciousness of incompleteness of preparation and a hope that, if called upon at all, the call may come for the facts that are in the pupil's meager store. Often the pupil's own initiative to home study must be supplemented by commands or entreaties from parents, and sometimes parents must do pupil's work for them, under penalty of family chagrin due to impending failure of the child. In most cases poor habits of study and an essentially immoral attitude toward study result from purported home study, though some pupils of good ability and strong individuality may do quite effective or superior work through home study. The habit of dawdling, waste of time in getting to work, wondering whether the work really must be done, whether a lexicon, cyclopedia, or parental answer to questions may not be found, leaves an entirely improper attitude toward real study. Sham work, at first as a makeshift, later becomes the only kind of which some individuals are capable.

Some important experiments have been made to determine the relative value of directed and individual class-room study.

It has seemed to several teachers to be worth while to see if more

carefully directed class-room study, less so-called recitation and less home work might not yield better results.

Experiments *in mathematics* have been carried on by Mr. Ernest R. Breslich, of the University High School (Chicago), Department of Mathematics. At the outset Mr. Breslich found that some pupils who did poorly on their assigned work did not understand the suggestions that had been given regarding good ways for undertaking the home work. Parents insisted that the assignments made were impossible, whereas for one reason or another the pupils had failed to get essential suggestions regarding the assignment. Even with assignments clearly understood certain habits of home study which did not exist had been assumed. A series of visits to other classes showed similar conditions. Pupils reported poor results from their home study, various excuses or no excuses being offered. The teacher explained away the pupil's difficulties and, in most cases, the pretense of having the work done at home was continued.

To ascertain the ways in which the members of one class attack their work, Mr. Breslich assigned a lesson, taking unusual care to make clear all phases of the assignment. The class was then told that the next fifteen minutes would be given to studying the lesson assigned. All pupils were slow in beginning the work and some occupied all of the fifteen minutes in getting ready to go to work. Some who ordinarily came to class with well-prepared lessons looked about to see how others were undertaking the work, and followed them. Few really accomplished anything in the fifteen minutes.

To investigate more carefully these individual habits of study, Mr. Breslich told his classes that at a certain hour each day the class room would be open to students who had difficulty with assignments or wished to make up back work, and good use was made of this opportunity. The teacher passed about among the pupils as they worked, making suggestions, but rarely answering questions directly.

It was then decided to make more prolonged trial of this supervised study with all members of one class. In one section of the class no home work was assigned and in the other section home work was assigned and in the usual way. The two sections had the same work. Both spent fourteen lessons on simultaneous linear equations, at the end of which the same test was given to both sections. The relative standings in grades which these two sections received upon the same examination, at the close of the preceding semester in mathematics, that is prior to beginning these experiments, are: Section A, average 81.4; Section B, average 79.4, B being slightly weaker than A. In Section B 5.9 of the class had failed in the preceding semester and none in Section A.

Section A was given home work with no class room supervised

study. Section B was given supervised study and no home work. Upon the test following the fourteen lessons their standings were:

Section A—with home work and no supervised study averaged 62.8, with 50 per cent. receiving the failure mark.

Section B—with supervised study and no home work averaged 65.5, with 31.2 receiving the failure mark. It is to be noted that Section B, a somewhat weaker section, surpassed Section A, and that its lower number of failures indicates that the poorer pupils profited most from the supervised study. Section A reported an average of 1¼ hours spent on each lesson, while in Section B the actual time of class work was 36 minutes per day. Section B solved an average of two problems more to each pupil than did Section A. With the supervised class work as a basis, too much time was spent on the home assignments. Section B worked slowly during the first three lessons, but with the development of independence and confidence they soon worked rapidly. The interest and pleasure of Section B, some of whom had failed in the preceding semester, were noticeable.

In the following topic to which six lessons were given, the methods were reversed, Section A being given supervised class-room work and Section B home assignments, and class recitations. At the close of this series of lessons the same test was given both sections with the result that Section A with supervised work and no home work averaged 77.5, and Section B with home work and recitations averaged 86.4.

12.5 per cent. of Section A failed on the test and 5.7 of Section B failed.

31.2 per cent. of Section A secured a mark of A, and 52.9 per cent. of B secured the A mark.

This seems to show that the pupils in Section B, by means of their previous fourteen supervised lessons, had learned enough about independent study to enable them to do their home work in such a way that Section A even under supervision did not surpass Section B in six lessons. The ability of Section B, gained under supervision, persisted in home study through six following lessons.

In the Detroit Central High School a different plan has been followed in some *experiments in algebra and Latin.* Principal David McKenzie writes:

> We have experimented somewhat with a plan to give additional direction to the weaker pupils of the ninth grade. I cite the two cases of first course in Algebra and Latin. At the end of ten weeks all pupils who were marked failing in these subjects were grouped together for special work in addition to their regular recitation periods. They were given twenty lessons each, on the ground covered during a period of six or seven weeks. Each pupil was treated as a pathological subject. In the final test they were marked as follows:

LATIN

Total number of pupils	15
Number marked "Excellent"	1
Number marked "Good"	6
Number marked "Fair"	3
Number marked "Weak"	1
Number "Not passed"	3
Number "Left"	1

ALGEBRA

Total number of pupils	20
Number marked "Excellent"	2
Number marked "Good"	4
Number marked "Fair"	3
Number marked "Weak"	5
Number marked "Not passed"	3
Number marked "Left"	3

It is plainly evident that a large number of ninth grade pupils need greater direction than they receive at present, and I am convinced that we must resort to some plan to give them this additional help, if we are to eliminate excessive mortality in this grade.

The *double period plan* is in use in many schools. In the Joilet Township High School for some years two periods per day, ten hours per week in all, have been given to all science work, manual training, domestic science and mechanical drawing, this period being used both for study and recitation. This school has also used this plan with beginning algebra, beginning geometry and beginning history. In Joilet the consensus of opinion of teachers is that the plan is successful. Principal J. Stanley Brown states that by such a scheme "the percentage of failures may be reduced to a minimum, and that is a compensation for the slight increase in teaching force and extra amount of money spent for teaching."

At Murphrysboro, Ill., an experiment (in *manual training*) has been under way which, while not bearing directly upon our question, has a collateral bearing upon it by indicating that even single periods and more prolonged periods of class instruction may sometimes be used in such ways as to make the shorter and not the longer period desirable, though doubtless longer periods usually are desirable.

A small class of boys in manual training was divided, one section being given single periods for this work, the other the same number of double periods. The principal, Mr. G. J. Koons, stated that the single period pupils were not above the double-period boys in their general class standing nor in ability. All were given piece work and records were kept of the hours used by each boy in completing each piece of work. Eleven pieces of work were completed by each pupil. The single period pupils used approximately 25 per cent. less time on an average for each piece than the double-period boys, and on the test given to all

at the close of the work, the single period pupils averaged 7 per cent. above the double-period pupils. This experiment suggests a possible waste of time in longer periods, possibly lack of readiness in attacking work, of attention and high tension of effort throughout the period. It is well known that appreciation of relative shortness of time available usually results in higher alertness, readiness of attack, higher tone and more constant prosecution of the work in hand. It must be kept in mind that the Murphrysboro experiment involves a small number of pupils and withal may be more of a suggestion of method than of the value of any particular length of period given to a study. Most teachers who have tried class-room directed study find double periods, part for study and part for general discussion, most effective.

Variations of the above experiment are under way in other schools.

Throughout the whole United States there has been a significant attempt to introduce courses in *general science* into the first year of the high school. While in different schools these courses vary largely in their content, length and in many details of method, they agree in their purpose of being less formal, less rigid and abstract than the highly differentiated sciences, and in selecting and treating topics in science in such ways that the pupils think through these topics with good methods of thinking and with a knowledge content that appeals to the pupils as being worth while. The dominant method is that of class study of real things and real situations. An active attempt is made to secure individual experimentation or individual study from every pupil. The whole general science movement is an attempt to secure a scientific method of work, upon concrete problems, the significance of which appeals to the worker. We have been putting first-year pupils into formal sciences which were beautifully organized and orderly, possibly even elementary from the point of view of the adult science and the research student, but which are an abstract field to the pupil who has not been led to rationalize the common phenomena of his surroundings. This general science course has met a splendid response and its method has resulted in more effective work in subjects other than science during the first year and in the sciences in the following years. It is stated by teachers and principals that where significant laboratory courses in general science are given, fewer pupils fail in their work, more remain in school in the second year, and there is a much larger demand in subsequent years for courses that utilize laboratory methods, similar to those of general science courses. The method and significant content of the general science course seems to prepare in ability to work and in desire to work in other laboratory courses. My own observation leads me to conclude that the oft-made statement that pupils are naturally averse to work, is much exaggerated. If properly guided to independent, purposeful study, really significant work becomes a pleasure to most pupils.

General science is an attempt to get back to the valuable parts of the natural history of our fathers, the purposeful, dynamic, thoughtful but elementary interpretation of common significant problems. The kind of interpretation which physiography promised to give when it first came into secondary schools and which physiography may still serve to unify better perhaps than any other single branch of science.

The more fully directed study in general science and in other laboratory sciences presents an opportunity for individual, first-hand study of concrete things for experiment and interpretation of phenomena. But, as is true in other high school subjects, it is wasteful for the science teacher merely to assure himself that the pupils and materials are enclosed within the same room. Science in which we boast of concrete studies, of the laboratory method and of the possible significance of content that is unsurpassed, has sometimes become as formal in its home assignments as unlikely of achievement, its recitations as free from individual dynamic activity as any other subjects. It as well as the other subjects needs to be revived by use of its own concrete laboratory method. Laboratory teaching in science or other subjects may rise to the highest level of excellence or may descend to a meaningless mechanical manipulation that is deadening. But it is believed that the laboratory method offers us an important method greatly needed in all our high school subjects, most seriously needed in the first years of the high school.

It must be obvious that if such methods of high school work as suggested by the experiments cited above are used, *some important changes must be effected.* Most important is wider recognition of real teaching, real development of pupil-power, as compared with assigning and hearing lessons and telling facts to pupils, in case they have not understood them. Recitations and class discussions and home assignments should not be wholly omitted, but these may profitably be much reduced. Then, when teachers direct their pupils in individual study of real situations, assignments may be expected to become more appropriate, more carefully planned, less frequently made at the close of the period as the class is starting from the room. The assignment is a highly important part of the period's work, and it is an educational misdemeanor to make an incomprehensible assignment.

The extension of these methods of study would help to eliminate some of the abuses of the ordinary class room recitation. With directed individual study, each would have fuller opportunity for work, and each must learn to work independently. It does not follow that all general discussion should be omitted, but in directed work there are ample opportunities for general discussions. Nor does it follow that no home work should be assigned.

A more intimate interest in each pupil is possible through class-

room study. The ordinary assignment of home work and class-room recitation method tends to reduce all the class to a base level. Class-room study enables the teacher better to teach both weak and strong pupil, to his highest efficiency. The ordinary class recitation method —a sort of vermiform appendix on our educational system—often consists either in allowing the best students to do the work or in having them sit idly by, developing habits of low tension while the teacher attempts to pull up the weaker ones to a fair understanding of the point at hand. It requires a higher order of ability to teach genius than mediocrity, and our present class-room methods often ignore genius, through an illy balanced sense of duty to the mediocre, or may neglect the majority in the interests of the few brighter pupils. Well-balanced study should enable the teacher to stimulate all to a high degree of effort.

Class-room study means a longer school day and more teaching force or longer hours for the present teaching force. The school day should be longer. Germany has approximately thirty school hours per week to our approximate twenty hours per week in secondary schools.

Almost all high-school work should be done at school in school hours under guidance of teachers. Less assigned home work will mean less carrying of responsibility for school duties during the hours at home when often such responsibilities can not be met and under conditions which often foster ineffective habits of study. There will always remain plenty of good home work; good reading, some assignment, upon work in line with school work; but our pupils should no more carry home with them the larger burden of their school work than a good business man should take home with him his major business duties.

The longer school day is not to be feared, but welcomed, if by means of it adequate time for proper study is secured. We have cheapened our schools by shortening them. Even longer hours for teachers, the time being given to more prolonged and more effective teaching in a reduced number of classes, is not undesirable, if by means of these longer hours more effective teaching and less wreckage through failure in high school may be secured.

HOW EUROPEAN AGRICULTURE IS FINANCED

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THE American farmer is ahead of the European in many things, particularly in the use of labor-saving machinery. But in the application of business principles in their financial operations, the European farmers have perfected systems that are in advance of anything yet attempted in America. This has been largely brought about by the force of circumstances necessitating an economic transformation. During the last century the competition of new countries with immense areas of virgin soil flooded the European markets with agricultural products and forced the European farmers to reorganize their business methods.

As a result they have organized to make available abundant credit at low rates of interest and on favorable terms of repayment. By credit, it is not meant that the farmer gets everything he buys on time without paying anything on it, and that he is in debt on every hand, but just the reverse. It means he has money available at all times, so that he may pay cash for everything he buys, thus getting the benefit of the lowest cash prices and discounts. His credit is at the bank and not at the store, and through the bank he gets the loans that he needs at rates of interest just as low and in many cases lower than secured by other industrial enterprises, no difference how large or how much business they do. But to accomplish this the farmers have had to take a hand in the banking business themselves. They have organized on a cooperative basis to secure the credit they need and to supervise its distribution rather than leaving it to private interests to supply the same. By so doing they have reduced rates of interest, lengthened the time for which loans are made, provided for the repayment of loans by annual installments, and they keep the money in the rural districts and prevent its accumulation in the large cities.

Sources of Capital

The sources from which the capital is drawn that is thus made available to the use of the farmers may be classified under three heads: (1) subvention from the government, (2) savings deposits of the farmers and rural population, (3) from the sale of bonds secured by mortgages on farm land.

The relation of the governments in furnishing agricultural credit has varied greatly. In France the rural banks have been established for the most part on funds advanced by the government without interest. This policy was begun in 1894 and in 1910 the working capital at the disposal of the rural banks which had state aid amounted to 71 million francs (between 14 and 15 million dollars), of which 40 million francs had been advanced by the government. In Austria the provincial governments have actively assisted in the establishment of rural banks to furnish credit for farmers and have advanced loans without interest to them. In Germany the government has indirectly aided the rural banks by establishing central banks founded on capital advanced by the government, in most cases at 3 per cent. interest. The central banks in turn furnish credit to the rural banks and the rural banks to the farmer. The Prussian Central Bank at Berlin now has a capital of 75,000,000 marks from the Prussian government. However, its business is not confined to agricultural banks, but is open to all kinds of industrial cooperative associations. It receives deposits and makes loans to the cooperative banks throughout the kingdom of Prussia, and serves as a compensating medium between the different cooperative institutions. For example, if a rural bank has large deposits and a surplus of funds, it deposits them in a central bank to be loaned to some other bank in need of funds.

The desirability of government subvention is a disputed point, and in Germany which has the best developed system of agricultural credit in the world, many are opposed to it as being entirely unnecessary and think that a better system can be developed without it.

The second source of capital, savings and deposits of the farmers and rural population, is the most important. It has the advantage of developing the habit of saving among all classes in the country and it keeps the money in the rural districts in which it is earned. In Germany alone there are over 16,000 rural savings and loan banks with one and one half million members and deposits of over $250,000,000. Instead of being deposited in savings banks to be loaned out in the cities, as is the case in America, or deposited in postoffice savings banks to be loaned to city banks, the money is kept in the rural districts and loaned out at a rate of interest that the farmer can use it to advantage.

The third source of capital, obtained by the sale of bonds secured by mortgages on farm lands, was the first form of cooperative agricultural credit established in Europe and was begun in Germany in 1770. Its most rapid development, however, has been within the last thirty years, and at the present time the German farmers have over $1,000,000,000 borrowed in this way, none of it costing them more than 4 per cent. interest and in some cases it is as low as 3 per cent.

Agricultural Credit in the Province of Saxony

The agricultural credit institutions of the province of Saxony in the kingdom of Prussia are as highly developed as in any place in Europe and are typical of the German system. The province of Saxony lies in central Germany, contains an area of 9,750 square miles and in 1910 had a population of 3,088,000, equal to 315.7 per square mile. The largest cities in the province are Halle and Magdeburg with 180,000 and 280,000 population, respectively. It is the heart of the sugar-beet district of Germany and the richest agricultural section of the entire empire. It contains 97,000 farms of over five acres in size. The estimated worth of the land per acre is $300 (for the whole of Germany it is $150 per acre). It is a typical agricultural province, in which the most intensive systems of agriculture have been developed, necessitating the investment of a large working capital per acre, which has been made available through the development of agricultural credit institutions.

These may be divided into two classes: (1) the institutions furnishing real credit, that is, loans secured on farm mortgages made through the public land mortgage bank—the so-called *Landschaft* of the province of Saxony, (2) institutions for furnishing personal credit, that is, working capital on short time loans and on personal security which is provided through the farmers' cooperative banks.

The Land Mortgage Association

The German Land Mortgage Association (*Landschaft*) was first established in 1770 by the nobility of eastern Germany, with the approval of Frederick the Great, for the purpose of securing loans on their farm real estates. Instead of borrowing individually they organized an association and issued a common mortgage bond against all of the real estate owned by the members of the association. Furthermore, the management of the association was under the direct control of the government and the officers were quasi-public officials. Other similar institutions were soon established, but confined their members to the nobility and large landowners. However, the results secured were so satisfactory, the rates of interest so low and terms of the loans so favorable that the plan extended and the farmers of the middle classes organized in a similar manner.

The province of Saxony, in which the farmers of the middle class predominate, did not organize a land mortgage association until 1864. A few years later came the war between France and Prussia (stopping industrial development) so that in reality the association did not make real progress before 1880. To-day the total mortgage indebtedness of the province is 830,000,000 marks, and over 220,000,000 marks of these loans have been made through the Provincial Land Mortgage

Association. The proportion of the loans made through the association is constantly increasing and within the last six months they have increased 10,000,000 marks, but the time probably will never come when all of the outstanding mortgage loans will be made through the land mortgage associations, as in many cases mortgages are given by members of families in settlements of estates, loans are made within families and through other private interests, so that in no case is it likely that over two thirds of the mortgage indebtedness of a province will be made through a public credit institution.

The Business of the Land Mortgage Association

The Land Mortgage Association of the province of Saxony, which is typical of all other similar institutions in Germany, is a cooperative union of the landowners of this province for the purpose of securing loans for its members on their land by issuing bonds (*Pfandbriefen*) against the same. The association is not a stock company. No profits are declared to individuals, but go to the reserve funds of the association. Any one may become a member who is a landowner in the province and pays a land tax of at least 90 marks per year, which means owning from 10 to 25 acres of land, depending upon its value.

The articles of the incorporation for the association were approved by the Prussian government and the oversight of the business is under the direction of the Minister of Agriculture of the kingdom of Prussia. The association is independent to conduct its own affairs and to elect its own officers, but the election of the higher officers must be approved by the government. A farmer wanting to borrow through the association makes his application. After examination of the title of his farm and finding it satisfactory he has the privilege of borrowing to two thirds the assessed value of his farm for taxation by giving first mortgage to the association for the amount he borrows. The association does not have the money on hand to make the loan, but secures the same, not by selling the mortgage, but by issuing what is known as a *Pfandbrief* or mortgage bond of equal amount to the mortgage and selling the bond. There are several features of the *Pfandbrief* that are characteristic. First, it is not secured alone by the mortgage of the farmer for whom it was issued but by all the mortgages and property of the land mortgage association. Second, it is transferable without endorsement at any time and is an impersonal security payable to bearer. Third, it is not a bond in the sense that it runs for a definite length of time, for there is no fixed time at which it matures. Fourth, the holder does not have the right to demand payment of the face of the bond—that is, to call in the loan—but the issuer—the land mortgage association—has the privilege of paying it at any time. For example, the bond may be called in and paid six months after it is

issued or fifty years, at the pleasure of the land mortgage association. But under no conditions is the amount of bonds outstanding permitted to exceed the amount of mortgages held by the land mortgage association.

The business of the land mortgage associations has been done so conservatively that their bonds are regarded as the very best of security and are favorite investments for trust funds, savings banks and any capital seeking a perfectly safe investment negotiable at all times. In fact, these bonds sell next to government bonds, and in case of war, or even threatened war, they sell better. The government may be overthrown or compelled to suspend payment of interest, but the farm real estate that secures the bonds can not lose its value.

The rate of interest the bonds bear is 3 per cent., 3½ or 4 per cent., at the option of the farmer securing the loan, but the price at which they sell depends upon the condition of the money market. At the present time (July 1, 1912) 3 per cent. province of Saxony *Pfandbriefen* are selling at 81.00, 3½ per cent. at 90 and 4 per cent. at 99.80, while the 4 per cent. national bonds of Germany are selling at 100. In case a farmer borrowing $1,000 chooses a 3 per cent. interest rate and the 3 per cent. bond are only selling for 81.00, he gets only $810 and pays $30 per year interest, that is, 3 per cent. on the face of the bonds, and gives his note and mortgage for $1,000. But on the other hand, if 4 per cent. bonds are selling at par and he chooses a 4 per cent. loan, he gets his $1,000 in cash for his *Pfandbrief* and pays $40 per year interest and gives his mortgage and note for $1,000. It is always regarded as the best policy for the borrower to choose the class of bonds selling nearest par, unless they are selling above par, in which case the farmer securing the loan gets a premium over and above the amount of his liability and it is to his advantage to take such loans. When the bonds go above par they are called in and paid off by the farmers refunding their debts at lower rates of interest. Here comes the advantage that the farmers reserve for themselves in the privilege of paying off the bonds at will. Just such a thing happened when in the seventies the rate of interest advanced to 5 per cent., due to the scarcity of money and the enormous demand for it in building railroads on the continent and ten years later the rates of interest sank until 3 per cent. bonds sold close to par and the farmers rapidly paid off their loans made at the high rate of interest by using new bonds at the lower rate of interest and selling them to pay off the old ones.

Central Land Mortgage Association

In order to widen the market for the *Pfandbriefen* a central land mortgage association was established in Berlin in 1873. By this means it was thought to make them an international security and to give them

a larger market. The bonds of the central association are secured by all the mortgages of the provincial associations belonging to the central association. The results attained through the central association, however, have not fulfilled expectations. The *Pfandbriefen* in no considerable extent have found their way into the international money markets. The offering of them in such large quantities on the Berlin Bourse reduced the price below what they could be sold for in home markets through the local banks. Furthermore, there is a sentiment among investors buying bonds that as long as the provincial bond is equally as secure as the central they prefer to invest in *Pfandbriefen* of their own province. In the province of Saxony, with its 220,000,000 marks of *Pfandbriefen* outstanding, the director of the *Landschaft* estimates that 75 to 80 per cent. of the total amount invested in them is capital of the province of Saxony. So far as security was concerned, nothing was to be gained by consolidation into a central association, since the provincial association bonds are as secure as bonds can be made.

Of the total amount of bonds in circulation at the present time only about 10 per cent. of them are central association bonds. The latest statistics show that the provincial and central association of Prussia have the following amounts of outstanding bonds.

Land Mortgage Association of Prussia

Association	Founded	Outstanding Bonds
East Prussia	1788	426,152,350 M.
West Prussia	1787	123,074,405 M.
New West Prussia	1861	186,278,210 M.
Berlin	1868	449,563,500 M.
Pomerania	1781	252,007,525 M.
New Pomerania	1871	19,006,900 M.
Posen	1857	301,525,300 M.
Silesia	1770	608,634,180 M.
Saxony	1864	126,675,600 M.
Celle	1790	15,579,100 M.
Hanover	1825	24,706,650 M.
Bremen	1826	10,360,425 M.
Westphalia	1877	74,554,300 M.
Central	1873	433,255,000 M.
Total		3,093,493,545 M.

Mark equals 23.8 cents.

Amortization of Loans

One of the most valuable features of the loans made through the land mortgage associations from the standpoint of the farmer is the gradual amortization through annual payments made with the interest. This is obligatory on the part of the borrower and usually is ½ per cent. to ¾ per cent. of the face value of the loan. In the land mortgage

association of the province of Saxony the amortization is $\frac{3}{4}$ per cent. per year. On a loan made at 4 per cent. is added the $\frac{3}{4}$ per cent. amortization and $\frac{1}{4}$ per cent. to cover the operating expenses of the association, making a total of 5 per cent., and by paying this amount annually for between forty to forty-five years the loan will be paid off. The farmer in the meantime also has the privilege of paying it all or in part at any time. After the loan has been made the rate of interest can not be raised or the loan called in, so if the farmer has secured his loan at a low rate of interest he can carry it until it has been amortized by his annual payments. The Saxon farmers who in the nineties borrowed at 3 per cent. and got par for their bonds are relishing this feature now that the rate of interest has advanced to 4 per cent.

However, many of the better farmers make no attempt to pay off their loans any faster than is required through the annual amortization payment, finding that they can get their credit cheaper in this way than any other and can make more interest on the money used in their business than they have to pay for it. The association also has the provision that when 10 per cent. of the original loan has been paid an additional loan can be made and in this way a farmer can continue to carry indefinitely practically the same amount of loan on his property if he finds it advantageous to do so. The average length of time loans run in Saxony is about twenty-five years.

By this method the farmer gets all the advantages of the money market if money is tight—the rate of interest goes up and the price of the *Pfandbriefen* go down when money is abundant and interest rates low the price of *Pfandbriefen* go up. The farmer through his bank watches the money market and takes advantage of the low points in interest rates to secure his loan, and once made he is safe from having his loan called in or his interest rate raised.

Decentralizing the Business

A practical point in the operation of such a business is to make it as convenient as possible for the farmer to do business with the land mortgage association. The province of Saxony is a territory nearly 100 miles square and the association is located in Halle, a relatively large city. For all of the farmers to come to the central association to negotiate their loans would be impracticable and would diminish the business very much. This problem has been solved by dividing the province into districts 10 to 15 miles square and in each district is a local officer of the association elected by the members in their annual meeting. This officer assists the members in getting their loans, sends in their applications, gives information concerning the association and looks after the business in his district. When property is appraised for loans, he is chairman of the committee making the appraisement.

When interest is not paid or a member is neglecting his farm, the local deputy, as he is called, serves as the medium between the association and the delinquent member. In this way the advantages and economy of a centralized organization and at the same time the benefits of a decentralized association—that is, one close to the individual farmer—are secured.

Personal Credit

While the land mortgage association is sufficient to provide the long-time credit that is needed by the landowner, it does not suffice to furnish the short-time loans that are needed to supply working capital, to buy seeds, fertilizers, livestock to be fattened, to pay for labor to grow crops and such operations as require capital for six to nine months. To the farm renter or any farmer who does not own land, the land mortgage association has nothing to offer.

To meet this need the rural banks have been established. The work of this class of banks had its beginning particularly with William Raiffeissen among the peasant farmers of western Germany about the middle of the last century. Raiffeissen saw the dire straits of the small farmers who were without credit and at the mercy of the usurer. He began by establishing cooperative associations to do their own banking, and there were four fundamental principles that he insisted upon that have been retained in the true Raiffeissen banks of the present time. First, unlimited liability of the members. This was necessary in the beginning in order to get any credit at all. All the members were practically without means and the question of limited or unlimited liability was of little moment to them.

Second. A restricted area of operation for the bank. This was confined to the district in which the members were all personally acquainted with one another. In European farming it is customary, especially for the peasants, to live together in small villages and not on single farms as in America, so that the boundaries for the operation of the bank were generally confined to a single village.

Third. No dividends to members. A low rate of interest, usually 4 per cent., was paid on the capital stock each member had invested in the bank, but all profits made over that amount were set aside in a reserve fund.

Fourth. No salaried officers were employed in the banks except the bookkeeper. The management of the bank was made a matter of honor, the work to be done without any mercenary compensation. The business was done in the most democratic manner possible. Every member was given a voice and made to feel he was personally responsible for the success of the business. Loans were made for specific purposes, for example, to drain a field. The committee considered the

advisability of the proposed expenditure in making the loan, the members of the bank all knew the plan of the member and were interested in his success, because in case the member failed and was unable to repay his loan to the bank they would all be losers.

Raiffeissen did another thing that is of utmost importance in rural banking. He adjusted the loans of the bank to meet the needs of agriculture. The farmer needs a longer time loan than the merchant or manufacturer. City loans for three and four months do not fit the business of farming. With the farmer 6 to 9 months is the shortest time for which he needs a loan. The time from planting a crop till it is harvested and ready to market is at least six months. The city merchant will turn over his money four or five times during the year but the farmer only once, so that the rural banks must make the loans for longer periods than is customary in the city. In case of crop failure in bad seasons loans must be allowed for still longer periods and in Raiffeissen banks these provisions were made.

From their beginning in the Rhineland the Raiffeissen banks have spread not only over all rural Germany, but almost all rural Europe. They have been modified to meet local conditions but with it all have kept in view the purpose of serving the needs of the farmer.

In studying the agricultural banking or credit system of a country the condition of the individual farmer must be taken into consideration. A system applicable to peasant farmers with small holdings, such as are found in many parts of Europe, is not likely to offer much of value for American farmers. But in a section in which the average wealth and stand of the farmers is on the same level as in America, a system that is proving successful may afford some good lessons.

Rural Banks in the Province of Saxony

Such a section is to be found in the province of Saxony where the rural banks are splendidly organized and doing a business of $100,-000,000 per year.

The first striking difference between these rural banks and the original Raiffeissen banks is that they are organized on a limited liability basis. The farmers of Saxony for the most part are well to do, but they vary greatly in their financial worth. The man whose property is worth a hundred thousand marks is not willing to become a member of a rural bank or a cooperative association of any kind with members who are worth only five thousand marks and agree to an unlimited liability for its members. Consequently the Saxon banks are organized limiting the liability of the members in proportion to the interest they have invested in the bank. The fundamental object of the rural banks is to furnish credit to their members for working capital at the lowest rates of interest possible and not to make a profit on their business. In the

province of Saxony there are 660 rural banks. These are small village savings banks with an average membership of about 100 farmers. They are the units of the farmers' cooperative organizations of the province. At Halle there are three central cooperative organizations, with all of which the local banks stand in relation and are members: (1) The Central Cooperative Bank, which does nothing but a banking business and whose members are cooperative associations instead of individuals. (2) The Central Cooperative Association for the purchase and sale of agricultural products. This, like the central bank, has for members associations instead of persons and does a wholesale business in buying and selling agricultural products. (3) The Union of Cooperative Societies, which oversees the management of the local societies, audits their books, furnishes uniform systems of bookkeeping and looks after the organizing of new societies and does the propaganda work in promoting agricultural cooperative work in the province.

In order to become a member of the Central Bank at Halle the local association or bank must take a share in it which is 300 marks. The number of shares that the local bank or association hold is in proportion to the amount of business it does. By virtue of holding shares in the central association it is entitled to make loans from it. The farmer goes to his local bank, of which he is a member and to whom he is known, and makes his application for a loan. The bank in turn applies to the Central Association with which it has credit and secures the money and it costs the farmer $\frac{1}{2}$ per cent. more interest than the local society pays the Central in order to cover the local costs of the society. The average interest rate charged by the Central Bank in 1909 was 3.92 per cent., in 1910 it was 4.34 per cent. and in 1911 was 4.39 per cent. The rate of interest paid for deposits is 3 to $3\frac{1}{2}$ per cent., depending upon the current interest rate.

Credit is the first requisite of successful cooperation. When a country has a well-established system of agricultural credits it is almost certain to be thoroughly organized on a cooperative basis in other lines. This is the case in the province of Saxony, particularly in the purchase of agricultural supplies, such as fertilizers, feeding stuffs, coal, seeds and agricultural machinery.

The local banks serve the farmers both as the societies through which the purchases are made and furnish the credit for making the purchases. In this way there is a saving in the cost of doing the business and the bank knows how the money is spent.

Moral Effect of Cooperation

The development of the cooperative credit systems among the farmers of Europe has had an important influence on their social life. Aside from the independence gained in their business affairs by being

freed from the money-lenders which for the most part were usurers, they have been united in a community of interest that has widened their circle of acquaintance, given them a sympathetic interest in each other's welfare and has largely displaced the jealously so commonly existing in rural communities.

Among the peasant classes where the Raiffeissen savings and loan banks were established with unlimited liability of the members, ministers have frequently testified that they have been as important factors in the moral life of the people as the church itself. Intemperance and immorality is not permitted among the members. If a farmer takes to intemperate drinking his loan is called in by the bank. If he is neglecting the work on his farm the loan is called in. So that every farmer feels he is under the constant watch of the other members and since they are united together in a cooperative association, where if one man fails the others must pay his losses, they are all interested in each other and anxious to see every one succeed.

The application of the cooperative principle of "one for all and all for one" serves as an incentive to the individual farmer and inspires him to do his best.

Need in the United States

The farmers of the United States as yet have not appreciated the value of organizing to improve their credit. In the southern states the cotton crop must be marketed as soon as harvested to meet outstanding loans that the farmers have made at exorbitant rates of interest. The grain dealers throughout the central states know that they will be flooded with wheat and corn just before tax-paying time by farmers who are compelled to sell in order to raise money to pay taxes. Intensive systems of farming that must be adopted to adjust American agriculture to present needs means a larger working capital for the farmer, he must use more labor, more commercial fertilizers, better seed and he must drain his land. The European farmer gets twice as large a crop yield per acre as the American farmer because he spends twice as much capital in producing it. He cultivates better, fertilizes better and he takes better care of his land.

Interest rates in general are lower in the United States than they are in Germany and yet the German farmer is able to secure his credit through his cooperative organizations at two thirds the rate of interest ordinarily paid by the American farmer. In addition the loans are made on much more favorable terms and the times and methods of repayment are adjusted to suit the business of the farmers.

The advantages of the farmers organizing to sell their credit for what it is worth are not all on the part of the farmer. But for the capitalist seeking a safe investment for his money they offer a security

that can be bought at any time and is always negotiable. Such organizations serve as an economic saving between borrower and lender. The man in America at the present time who wishes to invest his money in farm mortgages must seek out such loans personally or through an agent. The punctuality with which the interest will be paid and the loan when it falls due will depend upon the personality of the farmer. But such is not the case when the loans are made through a land mortgage association and the investor instead of lending direct to the farmer buys the bonds of the association; he then knows that his interest will be paid as punctually as on a government bond; that his security has a market value and can be sold for cash any day through his bank. The establishment of the land mortgage association and selling its bonds on the open market opens up a field for investment that is now practically closed to a large class of investors.

One thing to be emphasized in regard to the success of the European systems is the fact that it has been largely due to the direct oversight that the governments have had over them. Without this government relationship they could not have commanded the confidence of the public that they have. It is hopeless to expect an equal degree of success for similar institutions in America unless they are also organized under government control, at least to the extent that the public will have absolute confidence in their solvency.

A STUDY IN JEWISH PSYCHOPATHOLOGY

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THIS is preeminently the day of preventive medicine. The campaign started many years ago to educate the people in the manner of avoiding contagious diseases has gradually been extended to other fields, until now the prophylaxis of insanity is almost as freely discussed as that of puerperal fever. And this is as it should be. Though the recovery of the already insane and the feeble-minded is seldom permanently accomplished, the outlook for the final prevention of these conditions among the potentially insane is by no means hopeless. The work undertaken by such organizations as the National Committee for Mental Hygiene, and the various allied state organizations and societies having the same general end in view are well known, and although the good already accomplished in the way of educating the people in those habits of life and thought which tend to make the development of mental afflictions less likely, is as yet inconsiderable, it promises, in the long run, to bring forth excellent results.

More and more we are coming to a realization of the importance of a good heredity. All medical men are practically agreed upon this subject. In the prevention of feeble-mindedness it is the one essential factor. It is of hardly less importance in the prevention of insanity. In an article on the hygiene of the mind, a recent writer has said "An individual who comes from normal stock, abstains from alcohol, and is free from syphilis, and escapes accidental head injury is not threatened with mental alienation."[1]

Conklin in the "Mating of the Unfit" refers to the offspring of one normal man by two separate women, one a feeble-minded girl and the other a perfectly well-balanced individual. The descendants of the feeble-minded woman were 480 in number, and of these 143 inherited the tainted mentality. The normal woman had 365 descendants and not one of them was to be classed among the mentally defective.[2]

It is also universally agreed that the propagation of tainted stock is much more likely when there is a close inbreeding of such stock. The best should be bred to the best, but different types of the same strain and close blood affinities should be avoided.

A fact so generally conceded should be applied as far as possible to the principles of marriage between individuals of both the same and

[1] A. J. Rosanoff, reprint from *New York State Hospital Bulletin*, November, 1911.

[2] Editorial, *The Lancet Clinic*, March 7, 1912.

different races. If the science of eugenics deserves any practical application at all, it should insist upon a careful study of the every-day violation of its cardinal principle by a whole race who persistently refuse to practise the very doctrine which is essential to the preservation of a sound and healthy mentality. I refer to the Jews.

In order to further elucidate the subject and to make good this rather bold assertion, I propose to prove the following propositions: First, the Jews are a highly inbred and psychopathically inclined race. Second, the prevalence of mental affections among them is almost entirely due to heredity.

That the Jews are as a matter of fact racially pure is a statement that must not be taken absolutely in a literal sense. All races have received admixtures of some outside blood, but it is undoubtedly true that, since the time of the prophet Ezra and his campaign for racial purity which was begun at the time of the return from the Babylonian captivity, 536 years before Christ, the central stem of Judah has remained practically free from admixture with other races. Any student of the old testament can easily substantiate the statement that violations of the law against marriage with the heathen races, by which they were surrounded, were, from that time on, most summarily punished. The feeling against such procedure grew in intensity until, at the time of the fight for the maintenance of Jewish independence under the Maccabees, it had reached such a degree of fervor that rabbinical decrees forbade friendly social intercourse with the Gentile on any pretext whatever. There is no doubt but that the Jews inter-married and inbred among themselves on an ever increasing scale clear up to the time of the fall of Jerusalem.

After the Dispersion, there is some difference of opinion as to the degree with which they maintained the racial purity which they had been over 600 years in establishing. The weight of evidence, however, is all in favor of the view that they did not abandon the time-honored doctrine of racial solidarity. During Roman times and the dispersion throughout the Mediterranean littoral, the rabbinical decrees were still vindictive in their treatment of the subject. To such extreme lengths did they go, that the *Goy* or Gentile party to the contract was regarded as having no right at all, but was considered like the slave, as having a status that rendered him incapable of connubium with the Jews.[3]

Those anthropologists who cite the fact that there were a great many converts to Judaism immediately after the fall of Jerusalem, and that the Jews thus received a great deal of Roman blood into their veins, overlook the fact that these converts were the very ones from whom the Christians in turn drew the majority of their converts. Thus the Judaized Romans were almost immediately lost to Judaism.

[3] Ephraim Feldman, "Intermarriage, Historically Considered," p. 19.

Likewise the alleged conversion of the Chazars, a Tartar tribe of Russia, was in reality confined to the ruling classes and their immediate court dependents, the main body of the people remaining free from the admixture with the Jewish proselytes.[4]

During the middle ages the Christians themselves put a ban on intermarriage and thus the rule against its practise was doubly enforced.

Since the time of Napoleon and the consequent removal of the political disabilities of the Jews, there has been no increasing tendency to take outsiders into the Jewish fold. Even in New York, where the social and business relations between Jew and Gentile are perhaps closer than in any other city in the world, there is practically no tendency to encourage mixed marriages. Although it is manifestly impossible to obtain exact figures upon this subject, all the obtainable data go to support the view that the inbreeding is going on here as much as in any other place in the world. M. Victor Safford, who has investigated extensively the results of immigration upon the ethnic composition of our population, has said that a study of the marriage certificates in New York City, while not giving sufficient grounds to absolutely prove the contention that intermarriage between Jew and Gentile is rare, does, nevertheless, justify the *belief* that such is the case.[5] The children resulting from such marriages almost invariably marry either Jews or persons who, like themselves, are only half Jews. Thus, what little departure there is from the principle against mixed marriages has no tendency to introduce fresh blood into the central stem. Hirsch has said that if all the Jews had remained Jews since the time of Christ that there would be 100,000,000 in the world to-day.[6] If we grant the truth of this rough approximation, it only serves to show that the result of all this "marrying out" has been an ever-increasing practise of inbreeding in the pure central stock. When we consider that the total number of the race is small, being probably not much over 12,000,000 altogether, we can easily see that there is not enough variety of blood among the members of the different Jewish families to avoid frequent consanguineous marriages.

Theoretically, the Jews are compelled to observe marriage customs which result in racial incest. Practically, it is well known that they really do marry their own cousins much more than do the people of other races. Jacobs says that they are probably three times as guilty in this respect as others.[7] I think we must concede the point that they are a highly inbred and closely related race. This fact undoubtedly accounts for the very strong racial characteristics which they possess.

[4] W. D. Morrison, "The Jews under Roman Rule," p. 413.

[5] M. Victor Safford, private communication, June 29, 1912.

[6] William Hirsch, "Religion and Civilization," p. 579.

[7] Joseph Jacobs, "Studies in Jewish Statistics," Appendix, p. 4.

I am not here concerned with any of those characteristics except the psychopathic ones. If they are endowed with exceptionally great mental gifts, it is beyond the scope of this paper to consider them. What I now propose to show is that they suffer from constitutional mental inferiorities, or psychopathic tendencies to a degree entirely out of proportion to the occurrence of such infirmities among the general population. First we will consider our own country. As fully two thirds of the Jews in the United States are in New York, it will be unnecessary to go out of that state to procure the evidence. In the year ending September 30, 1909, out of a total of 5,222 admissions to all the New York State hospitals for the insane, 488 were Jews.[8] While these statistics do not show the total number of Jews insane from all causes to be greatly in excess of the ratio which they bear to the general population, they plainly indicate that they do not fall below the general average, and when we come to analyze them in detail we find that they show a disproportionate number of cases due to constitutional mental inferiority. Taking those insanity groups which in all classifications are universally admitted to be due to bad heredity, the total number among the non-Jews was 2,297 or 48 per cent. of the total number of non-Jewish admissions. On the other hand, 65 per cent. of the Jewish insane belonged to the constitutionally inferior groups.[9]

TABLE OF ADMISSIONS TO THE MANHATTAN STATE HOSPITAL FOR THE INSANE CLASSIFIED BY RACE AND NATURE OF PSYCHOSIS FOR THE YEAR ENDING SEPTEMBER 30, 1908[11]

Psychoses	Irish	Jewish	German	U. S.	Italian	Negro
Senile psychoses	9.80	2.87	6.70	7.14	3.70	9.80
General paresis	7.59	14.05	20.10	17.46	9.87	29.41
Alcoholic psychoses	27.69	.32	11.85	11.90	8.64	7.82
(Dementia præcox)	13.48	27.47	14.95	16.66	23.44	13.72
(Manic-depressive insanity)	16.66	28.43	12.89	18.25	13.58	9.80
Epileptic psychoses	2.20	1.59	4.64	3.17	4.93	3.92
Other psychoses	22.58	25.27	28.87	25.42	35.84	25.53
Total number of each race	408	313	194	126	81	51

The practical freedom of this race from the alcoholic psychoses is a matter of common knowledge. Now alcohol was responsible for over ten per cent. of the insanities admitted to the New York state hospitals for the year ending September 30, 1909. But the Jews admitted for alcoholic psychoses for the same period constituted less

[8] Twenty-first Annual Report of the State Commission in Lunacy, Statistics of the Insane, tables 4 and 14.

[9] These percentages are deduced from tables 4 and 14, Statistics of the Insane, State of New York, 1908–09.

[11] De Fursac and Rosanoff, quoting Dr. Kirby in "Manual of Psychiatry," p. 6.

than one per cent. of the total Jewish admissions. Notwithstanding the fact that the Jews are thus almost entirely uninfluenced by the greatest of the acquired or accidental causes of insanity, their total number of insane does not fall to the level of the average for the general population. Thus out of 1,762 admissions to the Manhattan State Hospital for 1910–11, there were 455 Jews; that is to say, they made 25.9 per cent. of the total admissions. This is nine tenths of one per cent. more than their usually estimated relation to the general population of the community from which they were recruited.

Reliable data from foreign countries serves to show that, notwithstanding his freedom from alcohol, the Jew still contributes more than his share to the general insane population. Thus in Germany for the period 1890–1902 there were to the 100,000 of population, an annual average number of 67 insane and feeble-minded Jews as against 49 of the non-Jewish population. The congenital idiocies and congenital imbecilities showed an especial disproportion against the Jews, they having 4.51 as compared to 2.75 among the non-Jews.[10] That the proportion of the constitutionally inferior is especially large is shown by a reference to the subjoined table, which is taken from De Fursac's and Rosanoff's latest work on psychiatry. It will be noted that notwithstanding the fact that they have practically none of the psychoses which are due to alcohol, the Jews come second in point of number of admissions.

In this connection the percentage of the Irish admitted for alco-

TABLE OF MENTAL DEFECTIVES AMONG IMMIGRANTS (IDIOTS, IMBECILES, FEEBLE-MINDED). ANNUAL REPORT COMMISSIONER GENERAL OF IMMIGRATION, 1911. REJECTED FOR THE YEAR 1911

	Total	Mental Defectives	Per 100,000
Finnish	9.779	0	0
Russian	18,721	0	0
Spanish	8,068	0	0
Magyar	19,966	1	5
Greek	37,021	2	6
Dutch and Flemish	13,862	1	8
Scandinavian	45,859	4	9
Bohemian (Czech)	9,223	1	11
Ruthenian	17,724	2	11
Pole	71,446	9	12
Slovak	21,415	3	15
Italian (North)	30,312	5	16
Croatian, Slovenian	982	2	22
Italian (South)	159,638	36	23
English	57,258	13	23
German	66,471	15	23
Scotch	25,625	6	23
Irish	40,246	11	27
Hebrew	91,223	26	28
French	18,132	6	32

[10] Maurice Fishberg, "The Jews: A Study of Race and Environment."

holic psychoses exactly equals that of the Jews admitted for dementia præcox. Now, dementia præcox is classed as one of the insanities depending upon a constitutionally inferior mental make-up, as is likewise manic-depressive insanity. These two constitutional inferior groups which are universally agreed to rest upon a bad heredity, alone account for over 55 per cent. of the insanities among the Jews in the above table. Statistics could be multiplied almost indefinitely to show similar results.

Among the frankly feeble-minded, the Jews stand next to the top of the list of those immigrants who are deported on this account. The report of the Commissioner General of Immigration for 1911 shows that the French are the only ones who surpass them. In this connection it is well to note that over one half of the French immigrants for the year 1911 was recruited from the ranks of the French Canadians, who are a notoriously inbred and defective stock.

If it be objected that the foregoing table represents one year alone and can not be properly used to aid in drawing such wholesale conclusions, the answer is two-fold. In the first place this was a year in which the general average of Hebrew defectives was proportionately smaller than in other years. For instance, in 1907 nearly one third of those certified at Ellis Island as mentally defective were of this race, although they did not average over 14 per cent. of the total number of arrivals.

In the second place the number of feeble-minded children in the public schools of New York City is disproportionately large among the Jews. Thus of 317 mentally defective children selected at random from ungraded classes, Miss Anna Moore in 1911 found that there were 130 Hebrews, 40 Italians, 35 Germans, 20 Irish and 9 negroes.[12]

An attempt has been made to deny the ethnic or racial relation with the greater prevalence of feeble-mindedness and insanity, which the foregoing data would naturally seem to indicate. Thus it has been said that the birth-rate among the Jews being lower than that of the general population, there is consequently a larger proportion of adults among this race as compared with others, and insanity being chiefly a disease of adults, it follows that its greater prevalence among the Jews is apparent rather than real.

To explain the large number of feeble-minded the argument runs in this wise: Although the birth-rate among the Jews is low, Jewish parents take better care of their children than others, consequently more survive those illnesses which result in mental deterioration.

The chief fallacy in this argument lies in the fact that those who use it neglect to state that feeble-mindedness is overwhelmingly a dis-

[12] Miss Anna Moore, Report published by State Charities Aid Association, 1911.

ease of childhood, death for one cause or another intervening in the majority of instances long before the age of the natural expectation of life is reached. When we consider this universally admitted fact, it becomes apparent that at least one of the aforesaid explanations must be wrong. For, if children of Jewish parents survive in such disproportionately large numbers as to account for the seeming excess of feeble-mindedness, it naturally follows that this survival must offset the diminished birth-rate and serve to maintain the normal relation between child and adult population.

If the difference in the relation of adult to child population really exists in a sufficient degree to be a factor at all in the explanation of the degree of prevalence of insanity and feeble-mindedness, the logical argument would be as follows:

1. The proportion of Jewish adults to the general population is greater than among others, consequently the proportion of the child population is less.
2. Feeble-mindedness is a disease of childhood.
3. Conclusion: Being fewer Jewish children there are fewer feeble-minded among Jews than among others.

If we reverse the argument and assume the premise that more Jewish children survive than among others we should have the following syllogism:

1. The proportion of Jewish children to the general population is greater than among others, consequently the proportion of the adult population is less.
2. Insanity is a disease of adults.
3. Conclusion: Being fewer Jewish adults there are fewer Jewish insane.

A consideration of the foregoing examples of *reductio ad absurdum* only serves to confirm the belief that, after all, there must be some intimate relation existing between the racial, or inherent ethnic characteristics of the Jews and the greater prevalence of insanity and feeble-mindedness among them. In no instances shall we find any reliable data that show the proportion of feeble-minded and insane among the Jews to be less than among the general population; in most countries it is undeniably larger, and in every instance the number of Jews suffering from mental defects are recruited from the ranks of the congenitally inferior in a far greater proportion than is the case among the non-Jews.

In the light of our knowledge of the laws of heredity, there can be but one thing responsible for the above-described condition. It must necessarily have been brought about by too close inbreeding.

That the excessive number of constitutional inferior insanities has a partial explanation in the fact that long centuries of inbreeding have

produced a race with a paranoid make-up seems not altogether improbable. The general paranoid attitude of the race is shown in an almost universal tendency to assume the possession of superior racial mental qualifications, and when these are denied or in any way gainsaid, to fail to appreciate the point of view of the one who opposes them.

This idea of superiority to other people is so inbred that it has probably become a hereditary character for which the individual is entirely irresponsible. But a paranoid make-up is not particularly dangerous to its possessor who is otherwise normal, unless by great stress or a very unusual combination of disagreeable experiences this tendency be diverted into abnormal channels.

The chief danger lies in the accentuation of the character by too close inbreeding with those having a like tendency. In fact, the general attitude of the person who has this paranoid make-up in a mild degree may be said to be an enviable one rather than otherwise. He is aggressive in upholding his rights, suspicious of attempts to thwart him in the pursuit of the same, and strives constantly to reach the goal of his ambitions. These are all admirable traits. It is only when they become accentuated to the point where they are pervaded by delusions of grandeur and persecution, that they render the person possessing them a menace to society.

To return to the thought expressed at the beginning of this paper, that the prevention of mental diseases is quite the most important part of their treatment, it would seem that the Jews have it in their power to ultimately stamp out the feeble-minded and insane from among their race. The way in which they can do this must be plain to whoever has followed the gist of my argument. It is all a question of eugenics. A little more care in the matter of consanguineous marriages and a quick and thorough departure from the old beaten tracks which forbid the introduction of non-Jewish blood into their veins, will, in the course of a few generations, redeem them from the unhappy mental state into which they have fallen.

THE LANGUAGE OF METEOROLOGY

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IN discussing the vocabulary of any branch of science one is embarrassed by the fact that scientific language in general is a neglected subject. The principles of scientific terminology and nomenclature (on the etymological side) are not, to my knowledge, taught in modern curricula; their formal exposition belongs to the scholarly literature of a past generation; and the writings of our contemporaries bear evidence of the fact that philology does not now enter to so large an extent as formerly into the equipment of the average man of science.

The student of to-day is, as a rule, left to make his own generalizations on this subject from the transformations in the technical vocabulary that happens to come under his observation; and his inductions suffer in proportion as these transformations become less orderly. When he arrives at the creative stage, and is called upon to label his contributions to knowledge, he is apt to still further increase the disorder of the language; and thus an interaction is going on that would speedily lead to chaos, if it were not checked by powerful though unrecognized laws governing the development of human speech—a pervasive "Sprachgefühl" that saves the language from falling into rapid ruin, though it can not protect it from gradual deterioration.

The fact that the underlying principles of terminology and nomenclature are not, to say the least, clearly formulated in the minds of most men of science makes it desirable, in discussing a particular group of technical terms or names, to begin far back of one's subject—just as it is desirable for a newspaper writer on Halley's comet to begin by enlightening the public in regard to the heavenly bodies in general. However, it is not practicable to follow such a plan within the limits of a brief paper. In the present case I shall cut the Gordian knot by simply referring my readers to the two statements of fundamental principles that I have myself found most illuminating—viz., the fourth book of William Whewell's "Novum Organon Renovatum" and Dr. Lereboullet's article "Etymologie" in the "Dictionnaire encyclopédique des sciences médicales"—and proceed at once to a discussion of some salient features of the language of meteorology.

One curious fact about this language is that a considerable part of it is unknown to meteorologists. Hundreds of useful terms have been introduced to fill the gaps in its vocabulary—some highly felicitous, others at least tolerable—only to sink into speedy oblivion, leaving their places unfilled. Take, for example, the names of the isograms—and

the name "isogram" itself. The latter, denoting a line that represents equality of some physical condition on a map or diagram (the isotherm and the isobar being the most familiar examples, is a convenient generic term, the need of which must have been often felt long before it was invented, in the year 1889, by Francis Galton. Yet to this day it is unknown to most meteorological writers, who continue to use an awkward periphrasis to express this every-day idea.

Several meteorologists have drawn lines connecting places of equal evaporation; very few have ventured to give these lines a name. There is no inconvenience in referring once or twice in a scientific memoir to a "line of equal evaporation." Suppose, however, one needs to mention the same thing fifty times. One is almost driven to the necessity of substituting a single word for this long phrase; and thus certain writers have, in fact, coined the terms "isoatmic line" and "isothyme"; but neither of these has gained currency in the habitual vocabulary of meteorologists.

In all, some eighty meteorological isograms have been named; but of their names less than a score are generally familiar, and many are almost completely forgotten.

During the last two or three years the recognition of the importance of the "barometric tendency" in weather forecasting has made us tolerably familiar with the "isallobar"; but what of the "isallotherm"? Lines of equal temperature-change have been drawn on forecast charts for a great many years. Their name, however, has just been invented, and is hardly yet known to the practical forecaster.

There is a marked reluctance on the part of contemporary men of science to contribute to the scientific vocabulary. This is perhaps due to the growing ignorance of the principles of etymology to which I have already referred; though it may be also the token of a reaction from the pedantry of an older generation, which cumbered the language with terms too labored for daily use, and often with names of things that might well have been left nameless.

I have in mind a number of lexical curiosities that furnish diversion to any one who chances to read a memoir by A. Piche, "La Météorologie dans le Département des Basses-Pyrénées." From this work we learn that "meteorologistotheory" is the branch of science dealing with meteorologists; that "meteorologistopiry" has to do with experiments in the training and organizing of meteorologists; that "meteorologistonomy" relates to meteorological administration; that "meteorologistotechny" is the art of applying the laws relating to the production of meteorologists, their arrangement into groups, and the development of their labors; that "meteorologistosophy" is the philosophical study of meteorologists; etc. In short, M. Piche has stuck pins through his meteorologists as if they were so many butterflies, and has made them the subject of a new branch of natural history. His

terminology is so terrifying that we are thankful the meteorologists had individual names before he got hold of them; otherwise we shudder to think what he might have done in the way of nomenclature! The same ingenious Frenchman invented an instrument for measuring the sensible temperature which he called at first the "calorisoustractometer"; but later he took pity on humanity and changed its name to "deperditometer."

Of the two evils—a clumsy term or none at all—the former is certainly to be preferred. There can be no progress in ideas without a corresponding progress in language. This fact is emphasized by Whewell; and he cites in illustration the cases of Cæsalpinus in botany, and Willughby in ichthyology, each of whom introduced excellent systems of classification which failed to take root or produce any lasting effect among naturalists because they were not accompanied by corresponding nomenclatures. No one recognized this truth more clearly than Linnæus, whose great contributions to botany were surpassed by his contributions to the *language* of botany. Whewell quotes a maxim from Linnæus's "Botanical Philosophy,"

Nomina si nescis perit et cognitio rerum,

which ought to be taken to heart by the many scientific men of to-day who are conspicuously shirking their obligations to the technical vocabulary.

In the history of meteorology there are innumerable instances of important ideas that led a precarious existence for years, almost ignored by meteorologists at large, because no one had crystallized them by giving them names. Think of the number of conceptions that owe their present definiteness in our minds to the felicitous terminizing of Ralph Abercromby! The seven typical forms of isobars are familiar examples. Another is the generalization "recurrence," under which term Abercromby united the many cases of the supposed tendency of particular types of unseasonable weather to occur from year to year at about the same period—Indian summer, the "Ice Saints," the "Lammas floods," the "January thaw," the "borrowing days," and a number of other similar interruptions in the regular march of the seasons—all of them more or less elusive when submitted to a rigorous analysis, but none the less deeply-rooted conceptions in the popular mind. Individually these supposed occurrences are familiar to all meteorologists, but we should probably sometimes lose sight of their generic similarity had not Abercromby given them a handy generic name.

Probably in no branch of science is the vocabulary more confused than in atmospheric optics; especially in English. This particular subject affords so many examples of the vices of the existing language of meteorology that we may profitably consider it at some length.

In a publication which, I regret to say, bears the official imprimatur of the Weather Bureau,[1] I find a definition of the "solar aureole, corona, or glory." These names are stated to belong to the familiar phenomenon of diffraction rings around the sun; and the question arises—Why three names for one thing? Etymologically one is as good as another; but the single term "corona" was long ago appropriated to the phenomenon in question. If we consult Pertner's "Meteorologische Optik," we shall find that, according to this authority at least, the aureole is *not* identical with the corona. A separate name was desired for that inner portion of the complete corona which is, as a rule, the only part visible; extending from the blue-white zone around the luminary to the reddish brown circle adjacent, but not including either indigo or violet. Pernter was, I believe, the first person to distinguish this part of the corona under the name "aureole." The glory, again, is something quite different. This is not seen around a heavenly body, but surrounds the shadow of the observer's head—strictly speaking, of the observer's *eye*—cast upon a cloud or fog-bank. In the phenomenon of the Brocken specter the glory constitutes the "Brocken bow"—though the specter and the bow are persistently confused in the dictionaries and in the literature of meteorology.

This leads us to a further hopelessly confused statement in connection with the definition above quoted, reading as follows: "A smaller circle surrounding the shadow of the observer's head is called an anthelion, aureole, glory, or fog shadow." The word "anthelion" has, indeed, been used persistently in this sense in English literature; though such a use has never been countenanced in French or German. Bravais and his successors applied the name "anthelion" to what is sometimes called in English the "countersun"; viz., a white image of the sun seen at the same altitude as that luminary, but opposite it in azimuth—one of the rarer phenomena of the great halo family. Although this, the preferable, use of the name is absolutely ignored in the English dictionaries—which uniformly confuse the anthelion with the glory—it is not quite unknown to English writers. I find the "anthelion," in this sense of the term (as observed in the year 1762), described and figured in the "Philosophical Transactions" (abridged), Vol. 11, p. 532. A similar use of the term occurs in Howard's "Climate of London," 2d ed. (1833), Vol. 1, p. 222. As to "aureole," we have already seen how Pernter has desynonymized this term. "Fog shadow" is obviously a most inappropriate name for a ring of *light*. In short, the sentence above quoted, revised in accordance with the requirements of accurate terminology, would read: "A smaller circle surrounding the shadow of the observer's head is called a *glory*." The three other names are untenable.

[1] *Monthly Weather Review*, Vol. 33, p. 527. This is, however, substantially a quotation from the Smithsonian Meteorological Tables.

Although I have quoted a Weather Bureau publication—because it happened to lie nearest at hand—the example selected is a fair specimen of the loose language of a majority of writers on atmospheric optics. In fact, the vocabulary is so confused that one can hardly write of any but the commonest of the photometeors without defining each term he uses: and I am not sure that even the names of the commonest are wholly unequivocal. In a recent number of *Nature*—a journal which is usually a purist in scientific English—the beautiful circumzenithal arc, Mascart's "upper quasi-tangent arc of the halo of 46 degrees," was referred to as a "zenith rainbow." Still more startling is it to find the new edition of Wood's "Physical Optics" ignoring the term "corona" altogether in describing the diffraction rings around the sun and moon.

In contrast to the prevailing confusion in the English vocabulary of this subject, we find that the labors of Pernter have led to the adoption of a nearly uniform terminology in recent German literature; but this writer shares with his compatriots a prejudice in favor of native terms that detracts much from the value of his contributions to the universal language of science. Thus, while he has adopted the Greek word "halo," he prefers to call a corona a "Kranz," and he clings to "Hof" as a general name for the heliocentric circles of all kinds. In fact, very few Greek or Latin names appear anywhere in his great treatise on atmospheric optics. Of course, this fact is merely typical of the almost universal preference of German science for linguistic isolation: a subject too large to enter upon here.

In French, the complicated terminology of halos was set in order by Auguste Bravais, and his labors have been admirably seconded in our own time by Louis Besson. Fortunately French science still prefers a Græco-Latin vocabulary, and the terms it introduces are easily taken over into English. No adequate account of halos has yet appeared in our language. Whoever undertakes to write one will hardly err in adopting the Bravais-Besson terminology *en bloc*, with only the necessary idiomatic modifications and without regard to the practise of earlier English writers on the same subject.

In the brief space remaining at my disposal I think I can not do better than to refer specifically to a few meteorological terms, of more or less recent origin, that deserve a wider use in scientific literature than they now enjoy.

Beginning at the top of the alphabet, I find that the branch of meteorology dealing with upper-air research is not yet known to all meteorologists as "aerology." This term, proposed by Köppen, and officially adopted at the Milan meeting of the International Commission for Scientific Aeronautics in 1906, is so well adapted to fill a serious gap in our vocabulary that one is surprised at the slow progress it has made in English. This is all the more surprising because, in

spite of its Greek etymology, it was promptly accepted by the Germans, and is now fully established in their language. The expression "scientific aeronautics," still incorporated in the name of the international commission that has the oversight of aerological matters, is an obvious misnomer as applied to the exploration of the free atmosphere, notwithstanding the fact that aeronautical methods and appliances are largely used in this field of research.

The most remarkable occurrence in the history of aerology was the discovery, in 1902, of a region of the atmosphere originally called by its discoverer the "isothermal layer"; a name that he has since abandoned in favor of "stratosphere." A number of other names have been proposed as alternatives—in some cases for reasons that, to any one familiar with the natural history of scientific terms, seem decidedly frivolous. Thus, some of our English confrères objected to the original name because there was no certainty that the so-called "layer" had an upper boundary—an objection that has perhaps been disposed of recently by Dr. Alfred Wegener. Mr. Dines, one of the ablest of aerologists, prefers to speak only of "isothermal columns" in the atmosphere; but this plan leaves the important stratum as a whole without a name. There is every indication at present that Teisserenc de Bort's second term, "stratosphere," will ultimately prevail. It commends itself by its consonance with the term "troposphere," applied by the same investigator to the region of clouds and convective disturbances, and with Wegener's recent tentative names for supposed higher strata of the atmosphere—"hydrogensphere" and "geocoroniumsphere"; and all of these conform to the well-established terminology of "atmosphere," "hydrosphere" and "lithosphere."

Meteorology has recently profited, as to terminology and otherwise, by the writings of Henryk Arctowski, who, though a Pole by birth and a Belgian by adoption, wields a very facile pen in English. M. Arctowski is responsible for the convenient words "pleion" and "antipleion," denoting, respectively, regions of positive and negative departure from a normal. Thus, a temperature pleion, or "thermopleion,"[2] lay over western Europe during most of the summer and early autumn of 1911. Lines of equal positive and negative departure from normal temperature (not "anomalies," which are departures of local means from the means of latitude circles) were unnamed until Arctowski called them, respectively, "hypertherms" and "hypotherms." All these terms are correctly formed from Greek roots, are easily assimilable into our language, and are well fitted to give definiteness to a group of ideas that formerly suffered in this respect by the lack of a terminology.

[2] M. Arctowski's terminology is not quite consistent, since he does not speak of "thermoantipleions," but of "thermomeions." As "antipleion" is an awkward form in combinations, it is unfortunate that it was adopted as the generic term. "Meion" is preferable.

Nevertheless, their use has not spread since they were proposed, two or three years ago. It is to be hoped that they are not destined to share the oblivion of some analogous terms relating to atmospheric pressure proposed about forty years ago by Prestel; viz., "pleiobar," "mesobar" and "meiobar."

Purely English terminology has received some useful amendments at the hands of Dr. Hugh Robert Mill, who in this respect is carrying on the worthy traditions of "British Rainfall." Thus he has balanced Symons's terminology of droughts—the "absolute" and the "partial" drought—by introducing the term "rain spell" for a period of more than 14 successive days with rain. This expression, however, like the term "rain day," is one that would need to be redefined in other countries. Dr. Mill has rendered an even more useful service to precise terminology by distinguishing between the words "mean," "average" and "general." He speaks, for example, of the mean temperature at Camden Square during the month of June, 1900; the average temperature at the same place in June during a ten-year period; the general rainfall over the whole county of London in May, 1910, and the average general rainfall over the same region for a term of years.

British meteorologists have also succeeded in establishing a working terminology in English for the various deposits of frozen moisture that have occasioned so much fruitless discussion at international meteorological meetings. The Meteorological Office now applies the term "rime" to the rough deposits due to fog, and "glazed frost" to the transparent smooth coating usually caused by rain which freezes as it reaches terrestrial objects. The ambiguous expression "silver thaw" has been discarded in British meteorology.

The endless subject of cloud terminology and nomenclature can not be discussed in this paper; but I wish to call attention to one term in this connection recently introduced by M. Besson. This is the name "nephometer" for an instrument used in measuring the amount of cloudiness, as distinguished from the familiar "nephoscope," by which we observe the positions and movements of individual clouds.

German meteorologists have lately introduced the all-Greek names "chionometer" and "chionograph," and the hybrid "nivometer," for the instruments used in measuring snow. Although these terms will hardly displace "snow-gage" in English, we shall probably find it convenient to use their derivatives: *e. g.*, "nivometric"; just as we use "pluviometric," though we generally avoid "pluviometer."

The name "ceraunograph" applied by Odenbach in 1891 to his variety of the thunderstorm-recorder now seems destined to become the generic and international designation for the numerous instruments of this class. Particular forms have been known as "thunderstorm-recorders," "lightning-recorders," "brontometers," "brontographs," "ceraunometers," "electroradiographs," etc. "Ceraunophone" will,

accordingly, be the natural designation of the modification of the ceraunograph in which a telephone-receiver takes the place of a recording pen.

Our Weather Bureau has recently contributed to the meteorological vocabulary the name "kiosk," applied to a little pavilion in which working meteorological instruments are displayed for the benefit of the public. Although the connotations of this word are hardly consistent with the style of architecture adopted for these structures in America, no better designation has been proposed, and it is safe to assume that "kiosk," as well as the object so named, has come to stay. It is rather curious that, although "Wettersäulen" have been familiar objects in Germany for half a century, their use has only recently spread to English-speaking countries, and the need of an English name for them has only recently made itself felt.

When the first complete English meteorological dictionary makes its appearance it will need to take account of fully ten thousand words and phrases; and in connection with hundreds of these much work must be done in tracing their vicissitudes and in bringing them into something like conformity with a systematic and workable language. The terms I have mentioned in the foregoing paragraphs are, in the language of the day, "a drop in the bucket."

In closing, I wish to repeat a recommendation that I recently made to the International Meteorological Committee, through the kind intermediation of the chief of the Weather Bureau, in behalf of the creation of an international commission on terminology, analogous to the commissions already established by the committee on various other meteorological subjects. The utility of such a step is well attested in the history of other sciences. In electricity, for example, the useful names of the electrical units—"ohm," "volt," "ampere," "coulomb," "farad," "joule," "watt" and "henry"—were all promulgated by formal international agreement.

The International Meteorological Committee and Conferences have, it is true, given us official definitions of a few terms; but such work can not be done on an extensive scale save by a body especially created for the purpose and having far more time at its disposal than is available at the ordinary triennial assemblies of meteorologists.

Pending the consummation of this wish, let me urge meteorologists to familiarize themselves with the neglected language of their science; to avoid coining needless synonyms of terms that already exist; and, when a new term is really needed, to create one with due regard to the analogies of the language and its availability for international use. Generally speaking, only Greek and Latin derivatives answer the latter requirement. If a meteorologist feels himself unequal to framing a valid word from the classical vocabularies, he can always appeal for aid to some friendly colleague of philological attainments.

THE SWEDEN VALLEY ICE MINE AND ITS EXPLANATION

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THE Sweden Valley Ice Mine, one of the unexplained mysteries of nature, is located about four miles east of Coudersport, the county seat of Potter County, Pa. A similar phenomenon is situated on Dingman Run, about three miles west of Coudersport. These are natural ice-manufacturing plants, running under full head during the warm season of the year, but shutting down entirely during the cold months of winter, when there is plenty of ice and snow to be had elsewhere and when it would seem to be the most natural time for the formation of ice at these places.

To learn something of the history of the Sweden Valley Ice Mine we must go back to the time when the Indians were the chief inhabitants of this particular section of the country.

A certain tribe knew the location of deposits of silver and lead, which they carefully guarded against discovery both by other bands of Indians and by the few white settlers in that vicinity. As the whites became more numerous the Indians were driven farther west, taking their mineral secrets with them, as well as the scalp of one white hunter who accidentally discovered one of their lead mines. For years accounts of these mines were handed down from one generation to another, until, having become partially civilized, the Indians returned to recover, if possible, some of their lost wealth. They came in bands of five or six and searched the country thoroughly in the vicinity of Coudersport and Sweden Valley, but without success. The country had been so changed by the advance of civilization that they were unable to follow the directions given them by their ancestors and were finally obliged to abandon the undertaking.

These strange, unexplained actions on the part of the Indians naturally aroused considerable curiosity among the residents. They surmised that the Indians were searching for minerals, and the ground was again thoroughly gone over, but with no better success.

A year or so later, in 1894 or 1895, a Cataraugus Indian came to Coudersport, got a lunch and walked off into the woods. After some time he returned with some fine specimens of silver ore which he exhibited to the amazed loungers who gathered around him. He then disappeared without telling any one where he was from, where he secured the ore or where he was going.

The result of this visit was only natural. Silver mining was the

topic of conversation whenever two or more persons got together. Another search was organized which resulted in the discovery of the Sweden Valley Ice Mine.

Mr. John Dodd and Mr. William O'Neil were prospecting near Sweden Valley when, underneath four or five inches of moss, they found a thin layer of solid ice. After leveling off a space about fifteen or twenty feet square they dug a shaft about six feet square by twelve feet deep. At a depth of nine feet they found petrified wood, impressions of leaves, ferns and other vegetation, also bones which were pronounced to be human. At a lower depth a peculiar kind of rock was found which they thought might contain gold or silver. Some of this

SHOWING THE OPENING AT THE TOP OF THE SHAFT.

was assayed and found to be of no value. At a depth of twelve feet an aperture was found from which came a cold draught. This was thought peculiar, but nothing was done to investigate farther and the work was abandoned.

The following spring Mr. Dodd found a considerable amount of ice in the mine, but thought that it had gathered there during the winter and had not yet melted. However, as the warm weather advanced, the quantity of ice, instead of melting as was expected, began to increase, and by the middle of July the sides of the shaft were covered with a coating of ice a foot or more thick and large icicles were forming from the opening at the top.

As winter again came on, the ice began to disappear until the cave

LOOKING DOWN THE SHAFT, SHOWING THE ICE-COVERED STEPS.

was nearly free from the summer's product. This phenomenon has regularly been repeated each year since its discovery.

Mr. Dodd, who owns the land, had a small building erected around the mine, leaving the roof, directly over the shaft, open so as to allow the rays of the sun to beat in upon the ice formation. The beautiful woods surrounding this spot make an ideal place for picnics and it has become a favorite place for visitors to spend an afternoon, and incidentally cool off.

Two years ago (1910) the bottom of the shaft settled eighteen inches, leading to an experiment by Mr. Dodd. He says that two sticks of dynamite were placed about eight feet back into a crevice at the bottom of the shaft and fired without turning a stone or dislodging any earth in the shaft. A possible conclusion is that there is a cave underneath the mine large enough to absorb the shock of the explosion. Nothing more has been done in the way of investigation.

The Dingman Run Ice Mine is a more recent discovery, being found on June 15, 1905, on Dingman Run on the farm of Mr. Pelchy. Mr. Pelchy, with the help of another man, was clearing up some brushland for farming when, in order to get a better foothold on the steep hillside, he tore away a little of the moss, which was several inches deep at that place, and found pieces of ice.

Having heard of the ice mine at Sweden Valley he began to dig in the hope of discovering a similar phenomenon on his own farm. He made an opening in the hillside ten feet deep by twenty across,

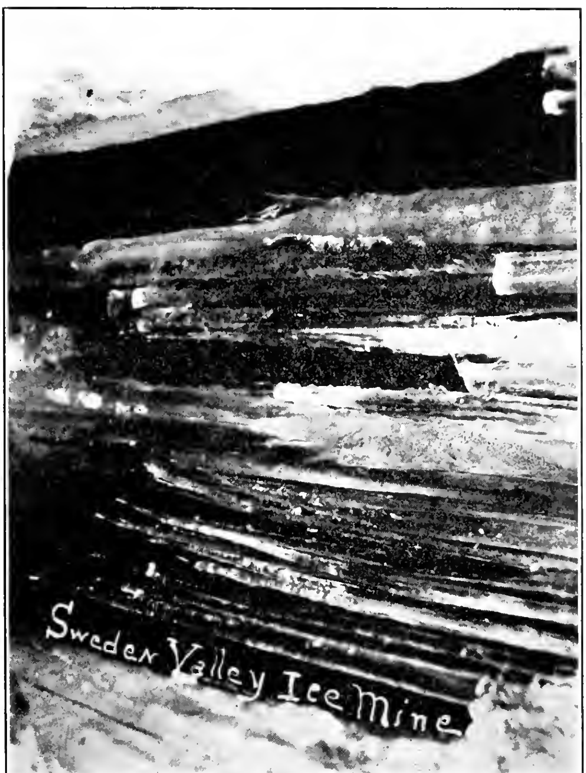
finding crevices in the rock from which he took chunks of ice weighing twenty and twenty-five pounds. Nothing more was done to bring this mine to the notice of the public and consequently it is known to but very few people even in Coudersport.

Although the Sweden Valley Ice Mine was discovered in 1898, it is practically unknown to-day. It is astonishing how many people within a few miles have never visited it nor heard of it. Recent inquiry (March, 1912) at the United States Geological Survey, Washington, brought forth the following response:

> There are in northern Pennsylvania, on the high plateau, several localities where, during the winter, snow and ice accumulate in large quantities under the protection of cliffs and caves, so that ice is obtainable from these sources during the succeeding warm season, but the Geological Survey has no knowledge of any ice mine in which ice is actually forming during the warm season.

The reason the U. S. Geological Survey has no record of these phenomena is that their survey in Potter County has never been completed and no atlas of the county has ever been published.

Further inquiry brought the following reply:



ICICLES FORMING FROM THE TOP OF THE SHAFT.

We find that phenomena similar to that described by you are not unknown and have been discussed in numerous papers. One of the best of these is the article on the Decorah Ice Cave and its explanation by Mr. Alois F. Kovarik, *Scientific American Supplement,* November 26, 1898, pp. 19158 and 19159. Dr. Samuel Calvin in his geology of Winneshiek County, Iowa (Iowa Geological

A VIEW OF THE INSIDE OF THE MINE, SHOWING ICE-COVERED STEPS AT THE RIGHT.

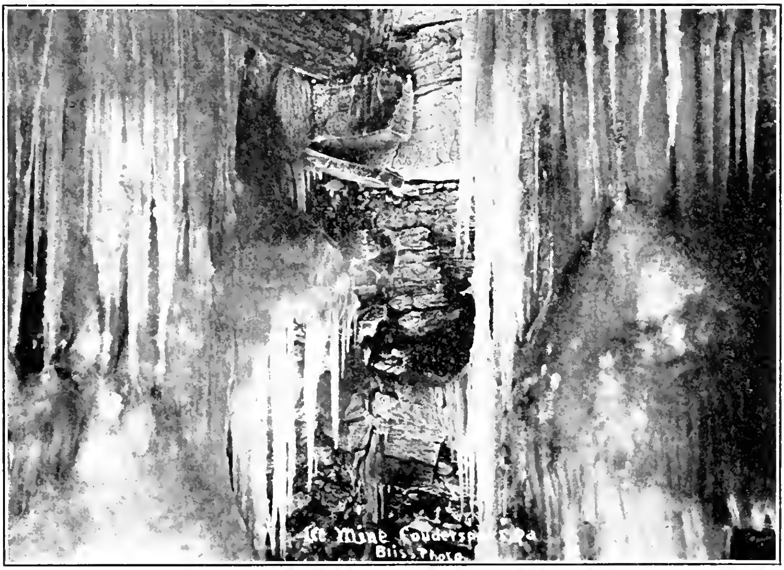
Survey, Vol. 16, 1905, pp. 142 to 146), describes this phenomenon and quotes at length from Mr. Kovarik's article, with approval. See also "Glaciers and Freezing Caverns," by Edwin Swift Balch, Philadelphia, 1900, pp. 88, 89, 177, 136 to 161; also "Ice Caves and Frozen Wells as Meteorological Phenomena," by H. H. Kimball, *Monthly Weather Review,* Vol. 29, pp. 366 and 509, 1901.

The writer looked through these references hastily and from Balch's "Glacieres or Freezing Caverns" the following is taken:

The natives and peasants in the neighborhood of Glacière caves generally believe that the ice of caves is formed in summer and melts in winter. I have met with this belief everywhere in Europe; in the Eifel, Jura, Swiss Alps,

Tyrolese Alps, and Carpathians: and also occasionally in the United States. Peasants and guides tell you with absolute confidence: "The hotter the summer the more ice there is." The strange thing is that any number of writers—sometimes scientific men—have accepted the ideas and statements of the peasants about the formation of ice in summer, and have tried to account for it.

The belief of the peasants is founded on the fact that they scarcely ever go to any cave except when some tourist takes them with him, and, therefore, they rarely see one in winter, and their faith is not based on observation. It is, however, founded on an appearance of truth: and that is on the fact that the temperature of glacière caves, like that of other caves or that of cellars, is colder in summer than the outside air, and warmer in winter than the outside



Another View of the Inside.

air. Possessing neither reasoning powers nor thermometers, the peasants simply go a step further and say that glacière caves are cold in summer and hot in winter.

Professor Thury tells a story to the point. He visited the Grand Cave de Montarquis in midwinter. All the peasants told him there would be no use going, as there would be no ice in the cave. He tried to find even one peasant who had been to the cave in winter, but could not. He then visited it himself and found it full of hard ice.

While the writer does not claim, as these peasants, that the heat of summer is the direct and only cause of the formation of ice, he does hold that it is an indirect cause and that the ice to be seen in the Sweden Valley Ice Mine is formed after the temperature outside the mine is far above the freezing point, and it is when the temperature outside is the highest that the ice is formed the most rapidly. The cause of this will be explained shortly.

The general skepticism regarding the existence of this phenomenon has been illustrated many times of late and has furnished the people of Coudersport with an endless source of amusement.

In the early part of the summer of 1911 a certain man of Detroit, Michigan, came to visit relatives in Coudersport. He was, of course, taken to see the ice mine, which was in its prime at that season of the year. Upon his return to Detroit he wrote a short article for one of the Detroit papers in which he told of this wonder that he had seen near Coudersport and offered to bet any one and every one $100 or more that his fictitious-sounding story was true. A millionaire ice manufacturer took the bet and eight other business men of Detroit followed suit. Two newspaper men were selected as stake-holders to decide the

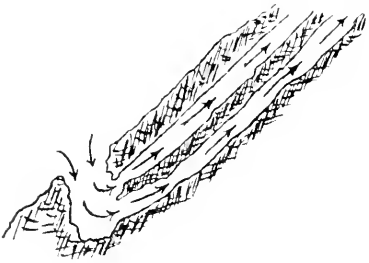
Petrified Wood taken from the Sweden Valley Ice Mine.

bets. They visited the mine and, of course, verified the newspaper story, much to the disgust of the nine losers.

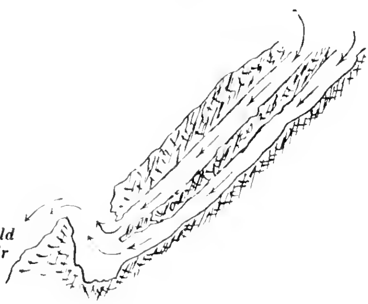
It is claimed by a great many persons who hear of this phenomenon, never by those who actually see it, in the summer time, that the ice is not formed during the summer, but is only an accumulation from the preceding winter. It was to prove the falsity of this claim that the writer visited the mine many times during the winter and spring of 1912. The existing conditions were found to be as follows:

The pit or shaft is about eight feet in diameter by twelve feet deep and, as shown in the sketches, is located at the base of a steep hill. In the winter time the pit is comparatively dry and free from ice. The temperature inside is the same as that prevailing outside. In the

spring of the year, as the snow on the hillside begins to melt and the frost comes out of the ground, water naturally begins to trickle down the sides of the shaft, where, strange as it may seem, it is frozen in the form of small icicles. This freezing process continues, until by July the sides of the pit are completely covered with a coating of ice a foot or more in thickness. In the early fall the process stops and the formation of ice gradually melts. The sides of the shaft are of loose shale, in which there are numerous crevices extending back and up into the hill, the rock strata being rather sharply inclined. A draught of cold air, which at some places is strong enough to extinguish the flame of a small taper, issues from these fissures in the summer time. This draught is variable, being stronger on hot than on cool days. A heavy mist may also be seen rising out of the pit and floating off down the hill close to the ground. The temperature of the pit during the past summer varied between 25 and 32 degrees Fahrenheit.



winter circulation



summer circulation

The explanation of this phenomenon appears to lie in the cold currents of air issuing from the crevices of the rocks along the sides of the shaft. The air must gain access to these fissures at some other point, which must be at a higher altitude than that of the pit, as will be seen from the following discussion.

This being true, it is evident that in the winter time the column of air directly over the pit is cooler and consequently heavier than that in the rock passages. Therefore, it forces its way down into the pit and up through the rock strata, chilling the rocks to a great depth and storing up a vast quantity of "cold." We see, then, that the amount of "cold" which is stored up, or the depth to which the rocks are chilled at the beginning of warm weather in the spring, depends upon the length and severity of the winter.

As the warm weather comes on the column of air over the pit becomes heated and is displaced by the cold, heavy air flowing down out of the passages. This cold current of air freezes any surface water which flows over the edges of the pit and maintains a freezing temperature as long as the supply of "cold" in the hill lasts, after which the circulation of air ceases and the ice formation melts.

The place at which air gains access to these passages need not be a single opening, but consists, in all probability, of numerous small apertures, covered possibly by a thin coating of moss, loose shale or other porous substance.

In the summer time the warm outside air entering these apertures comes in contact with the rocks which have been chilled by the reverse currents of the preceding winter and in doing so gives up its heat to them, becoming specifically heavier. It then forces its way on down, displacing the warmer and lighter column of air above the pit.

It is evident that the rapidity with which this circulation takes place depends upon the difference in temperature of the two air columns. That is, the cold outward current is much more noticeable on hot days than on cool days in summer, and in winter the strongest inward current is noticed on the coldest days.

This fact accounts for the common belief that the freezing takes place more rapidly and that the mine is colder on hot than on cool days.

The temperature of the mine, or, in other words, of the air as it issues from the crevices, remains practically constant throughout the summer, which is proved by thermometer readings. However, the difference between this constant temperature and the temperature prevailing outside the mine is obviously greatest on the hottest days and therefore, as one enters the mine, the contrast is more noticeable. This causes one to believe that the mine is colder when it really is not. It is true, however, that the ice is formed most rapidly during the hottest weather. This is not because the temperature of the mine is lower, as is generally supposed, but is due to the fact that the circulation of air is more rapid; that is, a greater quantity of cold air issues from the numerous apertures and consequently a greater amount of "cold" is available for the formation of ice.

As soon as the supply of "cold" in the rocks is exhausted the internal and external air columns become gradually equal in temperature and weight, the circulation ceases and the ice begins to melt. This generally occurs about September of each year.

If this is the true explanation of this phenomenon, we may say, with truth, that in this particular instance it is the heat of summer which causes the ice to form, but, at the same time, we can not disregard the fact that it is the severity of the preceding winter and the natural arrangement of the rock strata which make it possible for the heat of summer to produce this peculiar phenomenon.

WHAT BECOMES OF THE LIGHT OF THE STARS?

By FRANK W. VERY
WESTWOOD OBSERVATORY

ONE of the most astounding things in nature is the enormous energy which the sun is continually dispensing as radiation to surrounding space. The earth, as viewed from the sun, is a mere point in space, and receives no more than 1/2,200,000,000 of the radiant energy which the sun is outpouring so lavishly. Yet out of this small fraction of the total radiation, practically all the terrestrial activities of wind and wave, tropical hurricanes and avalanches of ice on alpine slopes and the no less potent but milder forces which clothe the earth with verdure, originate.

If we include all the planets in the solar system, and assess the outgoing solar rays at the maximum tariff imposed by the obstructions in their path, it still remains true that only 1/100,000,000 of their power is directly utilized in maintaining the thermal equilibrium and life of the attendant orbs, dependent from day to day for these gifts upon the dispenser of all of this bounty.

The solar outpouring for even a single day is inconceivably great, yet the same flux of energy has been going on ceaselessly and with very little change in its absolute intensity for at least a hundred million years, as the records of geologic time attest. If only one part of solar radiant energy in one hundred million is directly utilized, what becomes of the other ninety-nine million, nine hundred and ninety-nine thousand, nine hundred and ninety-nine? Remember, also, that our sun is but one among hundreds of millions of stars made known to us by our photographic telescopes, all outpouring similar torrents of energy, and the question comes home to us accentuated with many million-fold intensity.

Professor Comstock[1] has shown that the theoretical and observed distributions of luminosity among the brighter stars may be reconciled, if we suppose either that the intrinsically brightest stars have a "distinct tendency to cluster about the sun," or else that "there is a sensible absorption of light in its transmission through space, of such average amount that a star having a parallax of a tenth of a second appears one magnitude fainter than it would appear in the absence of absorption." Other modes of attacking the problem must be invoked in order to decide between these alternatives.

[1] George C. Comstock, "The Luminosity of the Brighter Lucid Stars," *Publications of the Astronomical and Astrophysical Society of America*, Vol. 1, p. 307.

The much more searching analysis of Professor J. C. Kapteyn[2] favors an actual absorption of light from the more distant stars, but a very much smaller one than that demanded by Comstock's result. Kapteyn's method, however, when applied to bodies more remote than the nearer stars, gives about the same amount of absorption for the easily resolvable clusters, N.G.C. 7078 and 7089, and for the irresolvable and very much more distant *Andromeda* nebula, which indicates that his absorbent medium is a local adjunct to these stellar masses, and that it is perhaps a meteoritic envelope of somewhat greater volume than the stellar agglomeration, but not a universal medium filling all space. The circumferential absorption or scattering depletion of light by a limited envelope can not be taken as an indication of nebular distance, but will vary with the constitution of the enshrouding meteoritic swarm.

To make apparent any general absorption of radiation by the interstellar medium, it becomes necessary to investigate the properties of space far beyond the limits of the Galaxy and its outlying shells of sparsely distributed stars, and, crossing the immense voids of surrounding ether, to inquire whether they contain other galaxies of dimensions comparable with our own, and whether these afford any evidence of a gradual absorption of luminous energy by the intervening medium.

The first scientific enunciation of the doctrine that there are such external galaxies was given in 1734 by Emanuel Swedenborg in his *Principiorum Rerum Naturalium*,[3] and Herschel's nebular discoveries lent some support to the doctrine; but it was not until after 1864 that further evidence really bearing on the question came. Then, spectroscopic examination at the hands of Huggins and his successors divided the nebulæ into two great classes of the gaseous nebulæ with spectra of a few bright lines, and the white nebulæ with continuous spectra. This furnished the first real criterion for a fundamental distinction.

The gaseous nebulæ are so closely associated with the Milky Way that they obviously belong to our galactic system; and Ranyard's recognition of wide, dark lanes or spots, often branching or dendritic in form, blotting out extensive regions on Barnard's photographs of the Milky Way, showed that not all of the gaseous bodies in its neighborhood are luminous, but that some are to be compared to a dark smoke or mist, obscuring the glories of the brightness which lies back of the widely extended and absorbent cosmic cloud.[4] Among the con-

[2] *Contributions from the Mount Wilson Solar Observatory*, No. 42.

[3] "Emanuel Swedenborg-Opera quædam aut inedita aut obsoleta de rebus naturalibus nunc edita sub auspiciis Regiæ Academiæ Scientiarum Suecicæ. Holmiæ, 1908." II Cosmologica-Pars tertia, Paragraphus prima, N. 8 et 11, pp. 271–272.

[4] See A. Cowper Ranyard's completion of Proctor's "Old and New Astronomy," where the subject is discussed at some length, pp. 739–746.

spicuously vacant spaces in the Milky Way may be noted those running east from *Rho Ophiuchi*, others east of *Theta Ophiuchi*, and mingled star clouds and vacancies in *Sagittarius* near 18½ hours right ascension and 11° south declination.

Since there exist these enormously extended masses of gaseous or misty material, capable, whether themselves luminous or dark, of exerting a strong absorption upon the light of any bodies beyond them, and intimately associated with the Milky Way; and since, further, it is inevitable that the broad disk of the galactic accumulation must have gathered into its vicinity great swarms of meteoritic material,[5] acting after the manner of a general, widely distributed mist, forming an envelope analogous to an atmosphere having its greatest depth in the direction of the galactic plane; it follows that this extensive quasi-galactic atmosphere and its associated, but locally limited, gaseous bodies must especially absorb the light from those distant galaxies which lie in or near the plane of the Milky Way. This, it seems to me, is the probable explanation of the extraordinary increase in the numbers of the white nebulæ near the poles of the Galaxy, namely, that the galactic quasi-atmosphere being thinnest along a diameter at right angles to the plane of the swarm, the light of external galaxies is best able to penetrate through the obstructions if coming from this direction.

Kapteyn's recognition of absorption by an interstellar medium also supports the above explanation, since he finds that the absorption diminishes in extra-galactic latitudes.[6] Professor Comstock, it is true, reaches a different result, finding that stars of the 10.5 magnitude have larger proper motions as their galactic latitude increases, whence he concludes that "at right angles to the Galaxy the limits of the stellar system fall within the range of vision," which may be correct, but his explanation that this is so because "the transmission of light through and that this medium offers little obstruction in the direction of the galactic plane does not necessarily follow. The simple explanation that the Galaxy is a discoidal aggregation of stars with limits less remote than is sometimes assumed, permits the supposition that the 10.5-magnitude stars in the galactic plane comprise many relatively bright stars at a double distance and having a mean annual proper motion of 0″.01, whereas the extra-galactic stars are the extra-galactic spaces is impeded by some absorbing medium,"[7]

[5] The central regions of a galactic accumulation of stars may be expected to be relatively free from meteoritic material, for here we have a space swept clean by the stellar attraction which gathers in the material and places it where it can be readily absorbed. In the more distant intergalactic spaces, the meteoritic material is widely dispersed, but upon the borders of the galaxies there are accumulations of finely divided matter, not yet incorporated in the stars.

[6] *Contributions from the Mount Wilson Solar Observatory*, No. 42, pp. 23–24.

[7] *Publications of the Astronomical and Astrophysical Society of America*, Vol. 1, p. 282; see also *Astronomical Journal*, No. 558.

soon cut off by the external galactic limits and have a mean distance one half as great, represented by a double proper motion of 0″.02. This hypothesis fits the observations and reconciles the conflicting results of the two investigators.

Among the many spiral or discoidal nebulæ there are some which have the plane of the disk presented edgewise, and which are foreshortened into long and narrow shapes, sometimes with a central globular condensation. Several of these elongated objects are centrally divided by a dark band. I take it that these dark bands represent the quasi-atmospheric element in question. One of the best examples is the nebula Herschel II 240 *Pegasi,* which is a fusiform object (as seen in projection) with a strong central condensation, and fading gradually towards the extremities. The bright mass is almost exactly bisected by a longitudinal black band, sharply defined, and about one fourth of the width of the bright part near the ends. It appears to be an equatorial belt of absorbent material, outside of, or an extension of, the margin of a luminous lenticular mass. Other examples are: HV 19 *Andromedæ,* HV 8 *Leonis,* HV 41 *Canum Venaticorum,* HV 24 *Comæ Berenices* and HI 43 *Virginis.* It is very probable that our own Galaxy is a similar disk-like aggregation of stars, involving spiral star-streams, and surrounded or interpenetrated by an absorbing medium which is most extensive in the plane of the disk.

In considering the absorption of light in space beyond the farthest reaches of the Galaxy, the investigation is best limited to luminous bodies of the galactic order which are neither themselves involved within the coils of our own starry system, nor situated in an extension of its plane, that is, we must exclude those objects whose galactic latitude is small. The latter, by the hypothesis, will consist of only a few near and relatively brilliant objects whose light has sufficient intensity to penetrate the galactic absorbent medium; but lest the distinction should be considered too fine, or too hypothetical, it may be waived in the present test.

I find only one nebula among those pictured by Mr. Isaac Roberts which is in a conspicuously vacant region. Of this nebula, H IV 74 *Cephei* = G.C. 4634 = N.G.C. 7023, Roberts says: "The nebula appears in a region almost devoid of stars." It is situated near the border of a branch of the Milky Way. Sir William Herschel has recorded *his* impression that nebulæ are apt to be found in regions which are poor in stars. This may be so, but an impartial examination of the photographs seems to indicate that the supposed connection between nebulæ and stellar vacuities is mainly a myth. It will require more extensive material than we now have to decide the point. Where such connection does undoubtedly exist, two different causes may be assigned for it: (1) a gaseous nebula *between* the Milky Way and ourselves may have a wide border of non-luminous absorbent material

which blots out the light of the more distant stars; and (2) the misty matter associated with the more condensed star-groups may obscure the light of external galaxies which therefore are better seen through the thinner places in our own stellar mass. Either of these causes would account for the stellar voids which Sir William Herschel describes as even a warning of the proximity of nebulæ; but it will be seen that there is no foundation for the inference which Mr. Herbert Spencer has built upon the supposed fact, namely, that none of the nebulæ can be external galaxies, *because* "thousands of nebulæ . . . agree in their visible positions with the thin places in our own Galaxy," and that they are necessarily most intimately linked with its structure. The connection, if established, will in no wise invalidate the wider generalization that external galaxies must appear to be most numerous in those regions where the mists or gaseous masses attendant on our Galaxy thin out and permit the light from the outside to penetrate the starry walls.

Mr. Roberts bears this testimony to the fact that the larger part of the nebulæ are situated beyond the confines of the Galaxy: There are "to be seen," he says, "stars apparently in a complete state of development, scattered over the surfaces of the most prominent of the nebulæ, but it will be observed that they do not conform with the trends of the spirals nor with the curves of the nebulous stars [or stellar condensations[8] ?] involved in them. This fact I apprehend to be strong evidence that they are independent of the nebulæ—that they are not in any way involved in the nebulosity, but are seen by us either in front, or else in space beyond the nebulæ. If they were beyond them, their light would have to penetrate through the nebulosity, and we should therefore expect it to be duller in character and the margins of the stars to be surrounded by more or less dense nebulous rings; but these effects are not traceable in the photo-images, and we are consequently led to adopt the alternative inference that they are between us and the nebulæ. If they were involved in the nebulosity, they would conform with the trends of the convolutions and appear like nebulous stars."[9]

The dark lanes in the Milky Way are sometimes called "rifts," a term which implies that the stars are distributed in a relatively thin sheet which can be rent asunder. Moreover, the word is not used in a merely metaphorical or descriptive sense, but in its full significance, as in the following quotation from "Worlds in the Making" by Svante Arrhenius (p. 173): "The presumption that these rifts represent the tracks of large celestial bodies which have cut their way through widely expanded nebular masses has been entertained for a long time." And

[8] Of the larger spiral nebulæ, Professor G. W. Ritchey says (*Astrophys. J.*, Vol. 32, p. 32, July, 1910): "All of these contain great numbers of soft star-like condensations which I shall call *nebulous stars.*" It appears not improbable that these represent irresolvable stellar groups.

[9] "Photographs of Stars, Star Clusters and Nebulæ," Vol. 2, pp. 23–24.

the same author explains the dark ring around the nebula near *Rho Ophiuchi* on the supposition that "the smaller and more slowly moving immigrants . . . are stopped by the particles of the nebulæ," and are detained by the gathering crowd. But even if it could be demonstrated that the stars are arranged in thin sheets, and that celestial bodies exist of sufficient size and momentum to plow their way through great aggregations of stars, demolishing everything in their track, it would still be exceedingly improbable that only one layer of stars should exist in a given direction, or that several rifts should coincide. On the other hand, the presence of widely extended masses of dark absorbent matter in the shape of branching streams, sheets or rings, situated *between* us and the depths of star-strewn space, is not unlikely.

The gaseous nebulæ which form a part of the galactic structure are often very extensive, and are of a great variety of shapes, being frequently strangely irregular; but the more numerous white nebulæ are formed more nearly after a common pattern, although still with infinite variation as to details.[10] In general, what is common to nearly all of the white nebulæ is a tendency to form a two-branched spiral, the branches issuing from opposite sides of a central condensation, and coiling either within the boundaries of a plane circular disk, or forming a helix around a cylindrical directrix. The former figure is the more characteristic, and is well exhibited in the *Great Nebula in Andromeda.*

Another very remarkable and at present unique type is the transient nebulosity which appeared around *Nova Persei,* issuing from the star as a center, and expanding into the commencement of a vortical ring. It was an electric phenomenon, an exhibition of canal rays, or positive ions, on a grand scale. Facts from the history of these two bodies will be found useful in preparing one of the necessary means for our quest.

It is obvious that we require for this investigation of external galaxies some scale of distances, and equally obvious that at present such a scale can be only approximate. Indeed, it is probably this uncertainty as to the scale on which the universe is constructed which deters astronomers from attempting to discriminate between different galactic orders. I propose to see if this uncertainty can be, in part, removed.

I propose to take the distance of the *Andromeda* nebula as our celestial "yardstick," which may be called one *andromede,* and assuming that when we consider a large number of nebulæ, the average size does not vary with the distance, and that consequently the average distances may be taken inversely proportional to the angular diameters of the objects, I shall classify the nebulæ according to apparent size and brightness. It is essential that the subdivision shall not be too minute.

[10] The class of white nebulæ exhibits various stages of development, and includes objects of mixed type. See E. A. Fath, "The Spectra of Spiral Nebulæ and Globular Star Clusters," *Astrophysical Journal,* Vol. 33, p. 58, January, 1911.

There is in nature a tendency to wide variation, coupled with a coordinate tendency to uniformity in averages, when the number of classes is limited. Thus the land mammals range in size from elephants, say 15 feet long, to mice and shrews of a few inches. If we divide the earth into a good many faunal regions, the average sizes of the mammals in the different provinces may vary considerably; but if we divide the earth into only two halves, the averages will be almost identical.

For the present research, I take Sir John Herschel's "General Catalogue of Nebulæ and Clusters of Stars," which, coming from a single hand, and that the hand of a master, may be considered fairly homogeneous; and excluding the clusters which are known to be associated with the Milky Way, and are therefore comparatively near, I divide the remaining objects into two classes: (1) large nebulæ, or those having a diameter greater than $2'$; and (2) small nebulæ, or those which are less than $2'$ across; and I shall assume that the small nebulæ are on the average farther away than the large nebulæ in the ratio, $x:1$, leaving the value of the ratio to be determined by considerations to be drawn from the result, and which will appear in the sequel.

A point-source of light diminishes in brightness as the square of its distance increases; but light from a large number of points so close together that they can not be discriminated must be treated as a luminous surface; and since the angular area of a surface also diminishes proportionally to the inverse square of the distance, the intrinsic brightness, or the brightness of the unit of angular area, does not change with the varying distances of the nebulæ. We must therefore inquire: Is the intrinsic brightness of a small, and therefore presumably distant, white nebula equal to, or less than that of a large one? If the average brightness of the unit of angular area is less for the smaller white nebulæ the presumption is that the light of the smaller and more distant objects has been absorbed in passing through space. To apply this test, I further subdivide each class into three groups—(*vf*) very faint, (*f*) faint and (*b*) bright, or, if desired, the last two may be combined into a single group.

Dividing the nebulæ in Herschel's catalogue into groups of four hundred each, and taking the ratios of the small to the large nebulæ in each of the thirteen groups, I find that without exception the *faint* and small nebulæ are more numerous than the *bright* and small in a relatively very much larger ratio than occurs in the corresponding divisions of the large nebulæ. With only three exceptions the same relation is obtained by comparing the *very* faint and the *faint* nebulæ. Treating the groups separately, and taking the mean of the ratios, I find

Small divided by large: *vf*, 8.38; *f*, 6.83; *b*, 1.48.

The sums for the entire catalogue are

Small: $vf = 1765$, $f = 897$, $b = 241$.
Large: $vf = 235$, $f = 172$, $b = 204$.

The division into separate groups with the result that the same general law is given by every one of the groups is of course the more severe test; but taking the ratios for the sums as answering our present purpose, we have for the ratio of

$$\frac{\text{Small nebulæ}}{\text{Large nebulæ}}: \quad vf,\ 7.51; \quad f,\ 5.22; \quad b,\ 1.18;$$

or approximately $vf : f : b = 6 : 4 : 1$; that is, the very faint nebulæ are in excess over the bright ones among the small nebulæ in the ratio 6 : 1, but are of nearly equal frequency among the large nebulæ. In other words, the large nebulæ are *intrinsically* much brighter than the small ones.

I next performed the same operation with the 744 objects in a "Catalogue of New Nebulæ Discovered on the Negatives" taken with the Crossley reflector at the Lick Observatory, dividing them into two groups: (1) very small, or not over one half minute in diameter, and (2) those which are above this size and which may be called "large." These groups were divided into two classes: (a) very faint, including those which are described as "very faint" and "*very* very faint," and (b) pretty bright, or those given in the catalogue as "faint" to "bright." The result of this examination is that *three fourths of the large nebulæ are pretty bright, and one fourth very faint;* while the very small nebulæ have *just the opposite distribution of brightness, three fourths of them being very faint, and only one fourth pretty bright.*

In comparing the two catalogues, it must be recognized that the photographic method is far more delicate. Most of the objects in the photographic catalogue could not be detected by visual examination. The photograph also includes faint margins and therefore increases the apparent size of such nebulæ as are visually perceptible. Consequently, Herschel's small nebulæ are about equivalent to the "large" nebulæ of the photographic catalogue, and we should expect that the photograph would include a much wider range of brightness—all of which is confirmed by a discussion of the observations.

Let us suppose that the average distances of the several classes of nebulæ are given in andromedes, and denoted by the letter a, and that the coefficient of transmission of light through space is t^a; also that the mean distances are inversely proportional to certain assumed apparent diameters which are fairly typical. Each class of nebulæ includes objects having a considerable range of actual diameter, that is, the variation of distance is not as great as that of the apparent diameter. Instead of taking a mean value of $\frac{1}{4}'$ to represent the diameter of that class which includes nebulæ less than $\frac{1}{2}'$ in diameter, I take

the upper limit of $\frac{1}{2}'$ as representing the class of very small nebulæ. For the intermediate class which includes those objects called "small" by Herschel and "large" in the Lick catalogue, and which may be designated as *medium*, I take a diameter five times as great, or $2\frac{1}{2}'$; and for Herschel's "large" nebulæ, I take a diameter of 5′. The reason for these selections shall now be given.

I take for the diameter of the *Andromeda* nebula, 110′. This subtends the longer axis of the oval figure of the more condensed spiral arms. The fainter extensions are omitted because these are seldom included in the more distant nebulæ. Taking a suitable value for the coefficient of transmission, the curves giving the relation between brightness and distance become congruous for the two catalogues, if we take x, the unknown ratio of distance for large and small nebulæ, equal to 2 for Herschel's catalogue, and $x = 5$ for the Lick catalogue. This gives the following sequence:

Nebular Class	Diameter	Distance	Transmission
Andromeda	110′.0,	$a_1 =$ 1.0 andromede,	$t = 0.996$
Large nebulæ	5′.0,	$a_2 =$ 62.5 andromede,	$t^a = 0.778$
Medium nebulæ	2′.5,	$a_3 =$ 125.0 andromede,	$t^a = 0.606$
Very small nebulæ	0′.5,	$a_4 =$ 625.0 andromede,	$t^a = 0.082$

The statement which was made for the ratio of brightness among the groups in the Lick catalogue (vf and $f + b$ for large and small nebulæ) can be repeated in identical language for Herschel's catalogue by merely substituting the fraction $\frac{2}{3}$ instead of $\frac{3}{4}$; that is to say, Herschel's nebulæ are not only nearer than the Lick nebulæ, but are more nearly at a common distance; and the fraction expressing the ratio of brightness for the two groups of near and distant objects among the Herschelian nebulæ approaches nearer to the value of equality which it would have if all of the nebulæ were at the same distance, for then there would be equal absorption, and large and small objects should be equally grouped about a mean value.

Ratio of brightness for large and for small nebulæ		
	If equidistant,	1 : 1
	Herschel,	2 : 1
	Lick Obs'y,	3 : 1 [11]

The absorption exerted by the medium between us and the nebulæ is in the main a non-selective one. If it were not so, but resembled the ordinary selective absorption of the planetary atmospheres, the most distant nebulæ should be deep red instead of white. Some selective absorption may, however, be exercised by the misty quasi-atmospheric envelopes which we have reason to believe are associated with some or

[11] For the details of this investigation reference may be made to my paper, "Are the White Nebulæ Galaxies?" *Astronomische Nachrichten*, No. 4536, Bd. 189, 441–454, November, 1911.

all of the galaxies; but these effects will be local and independent of the distance separating us from the galaxy in question.

If the intergalactic absorption is non-selective, and therefore not to be attributed to diffraction from particles comparable in size with the wave-lengths of light, nor to selective scattering produced by gaseous molecules, to what shall we refer it? We believe, on what seems to be good scientific evidence, that meteoric stones and meteoritic dust particles are strewn through the celestial spaces. Can they produce the depletion of the nebular light?

In part, no doubt, the light is absorbed by meteoritic material; but there is a fatal objection to the supposition that all, or even a large part, of the absorption can be produced in this way. If there were enough meteoritic dust to reduce the light from the most distant nebulæ to a small fraction, only this fraction could escape absorption. The rest of the radiant energy from the stars would be absorbed and reradiated from particle to particle, but without being able to escape, and the entire mass of meteoritic material accumulated in the untold depths of space must eventually glow. Long before this, the skies would become a scorching envelope. The universe would be a prison house. There would be no escape from its brazen walls.

Is there any other solution of the problem? I think that there is; but first let us get an approximate conception of the dimensions of this universe of galaxies. By combining the rate at which the nebulosity around *Nova Persei* expanded, with established principles from known physical laws, and noting further that the nova, like all of its kin, was a galactic object—a member of the condensed swarm of stars which constitutes our Milky Way—also that it was on the more distant branch of that mighty ring, I have deduced a first approximation to the dimensions of the more condensed portion of our Galaxy.

Next, I have passed from the Milky Way to the Great Nebula in *Andromeda* by asking how much farther the nebula must be in order that a new star which appeared almost at its very center in August, 1885, should have been comparable in brightness with a nova of moderate size in our own Galaxy. The answer is that approximately 1 andromede = 1600 light-years, or 15,000,000,000,000,000 kilometers.[12] An entirely independent computation, on somewhat different lines, by Mr. J. Ellard Gore, leads to a result of the same order. Mr. Gore is not quite as explicit as I have been; but the general agreement between our results makes me feel confident that we are not far from the truth.

No other of the white nebulæ compares with the *Andromeda* nebula

[12] In *Knowledge* for September, 1912, I conclude that Lord Kelvin's estimate of the diameter of the Galaxy, which was five times as great as mine, is probably the better of the two, whence it follows that 1 andromede = 8,000 light-years. But we are concerned at present with rough estimates of an order of magnitude only, and may waive all minute details.

in size, and their average distance apart may perhaps be ten times as great. We will suppose that each galaxy is at the center of an otherwise unoccupied cube 10 andromedes on an edge. The radius of a sphere containing 450,000 such cubes is 760,000 light-years. Now Perrine estimates that there are at least 500,000 nebulæ in the heavens within reach by the Crossley reflector, and probably nine tenths of these are white nebulæ or galaxies. It is therefore safe to say that the light of the stars can travel for one million years before becoming so much reduced by intergalactic absorption as to be beyond the grasp of this powerful instrument.

The view which I now wish to present is that it is the ether itself which absorbs the radiation from the stars.

Considered merely as to its volume, the ether is so overwhelmingly immense that all other bodies shrink into nothingness in comparison. The radius of the sun is

$$r_{\odot} = 7 \times (10)^5 \text{ kilometers.}$$

Half the distance to the nearest star is

$$r_* = 2 \times (10)^{13} \text{ kilometers.}$$

An ethereal sphere which may be called the sun's own, being bounded by the similar spheres of neighboring stars, may be drawn with the latter radius. The radius of the sun bears to that of its interstellar sphere the ratio

$$r_{\odot} : r_* = 1 : 30{,}000{,}000,$$

and the volume of the associated ether exceeds that occupied by the solar substance in the ratio

$$(r\ )^3 : (r_{\odot})^3 = 2.7 \times (10)^{22} : 1.$$

Since there are vacant spaces between neighboring galaxies, something must be allowed for these. Let us suppose that the ethereal volume is four hundred times greater than that just given, or that its volume ratio is

$$\text{Ether volume} : \text{Matter volume} = (10)^{24} : 1.$$

This allows a considerable extension of thinly scattered stars around each galaxy, and places the galaxies at relatively smaller distances from each other than the stars, if distances are expressed in terms of diameters, an arrangement which is indicated by the evidence already presented.

The next step in the argument demands an estimate of the total light from all of the stars. Call this L. Newcomb gave us such a photometric measurement, and found

$$L = 600 \text{ stars of zero magnitude.}$$

The brightness of the sun is

$$L' = 3.3 \times (10)^{10} \text{ stars of zero magnitude.}$$

Hence $$L' = \frac{3.3 \times (10)^{10} \times L}{600} = 5.5 \times (10)^7 \times L.$$

The average illumination in intergalactic space is very likely less than one one-hundred-millionth of that of sunlight; but a majority of the stars have less absorbent atmospheres than our sun, and as sunlight at the earth's distance must be increased in the ratio 1 : 46,000 to give the light emitted by the surface of the solar sphere, the average radiant energy at stellar surfaces may be assumed as $(10)^{12}$ times the average radiant energy in the star-lit ether.

If V and L are the volume and average illumination of the ether, V' = the total volume of stellar material, and L' = the total light from the combined surfaces of all of the stars, an instantaneous image of the relation between the two bodies—ether and matter—that is to say, a representation of the relation if there were an instantaneous emission of light with an infinite velocity, would give

$$VL : V'L' = (10)^{12} \times 1 : 1 \times (10)^{12},$$

or equality. But if the element of time enters, and also the actual velocity of light, the illumination at a given point in the ether will increase with the time. Let the year be the unit of time. After one billion years, supposing that the stellar radiation can have endured as long as this, instead of unity for the ratio $VL/V'L'$ as in the preceding equation, we shall have

$$VL = V'L' \times (10)^{12}.$$

Considering the limiting surface of the ether to be, not an imaginary circumscribing sphere, but the sum of the combined stellar surfaces across which the sum total of stellar radiant energy is being constantly transferred from matter to ether, the case stands about like this:

Volume	Radiation (Superficial)	Total Radiant Energy (Volumetric)
Stars $= 1$	Stars $= (10)^{12}$	Stars $= (10)^{12}$
Ether $= (10)^{12}$	Ether $= (10)^{12}$	Ether $= (10)^{24}$

The large amount of the total radiant energy of the free ether, compared with that of the stars may seem surprising, but it results from the fact that the average illumination of the ether is due to the accumulation of radiant energy from depths of space which are greater as the ether is more transparent. Unless the radiant energy were absorbed, it could not do otherwise than accumulate. The accumulation represents the combined radiation of an immense number of stars whose average distance is to be measured in millions of light-years—how many millions depends upon the time that the stellar radiation remains in the ether before it is all absorbed.

According to what precedes, the average ethereal energy can hardly be less than the radiant energy from the stars within a range of a million light-years, and may amount to many times this figure; and as

the absorption is a gradual one, the actual duration of luminous propagation may have to be reckoned in thousands of millions of years. Now the radiant energy of the ether represents its temporary mass. If we knew the relation between mass energy and radiant energy, we could give the ratio between the permanent energy of mass of the stars and the luminous energy of the ether. For example, if the mass energy of a star is on the average $(10)^{12}$ times its radiant energy, then the total energy of the universe is always equally divided between ether and matter, because the same radiation comes forth from unit volume of matter, and is distributed to $(10)^{12}$ units of ether. Or, if mass energy bears a larger ratio to radiant energy than this, energy may remain longer in its material than in its ethereal form, only a small fraction of the total energy residing in the ether.

To conjoin stellar centers and ethereal expanses, an intermediate order of existence is needed: An order which faces both ways, having relations with the ether and with the stars. Viewed from the side of ether, we begin to dimly apprehend an electric substance, not yet matter, although possessing many of its properties, seeming to be both a substance and a force, mobile, energetic, viscid enough to be localized and to take on intricate forms, a world-plasm, waiting to be incorporated.

Meteorites circulating around a galactic center remain for enormous periods in the neighborhood of their apogalacteum, and moving with extreme slowness, they have time to gather to themselves the scattered atoms of space, even though the attracting masses may average only a few grams. A meteoritic mass of 1 gram which, if quiescent, will attract to itself the particles within a radius of 1 meter in about 2 months, may be expected to leave a clean-swept track of considerable width through that part of its revolution which occurs in intergalactic space. Possibly the meteoritic chondri have thus grown by accretion in the depths of space, even if, as some suppose, their nuclei may have originated by condensation from masses of heated mineral vapor. Such a slow growth is not incompatible with various vicissitudes, and an eventual consolidation of many such masses into compound chondritic complexes, after the manner of the formation of large hail stones.

Particles which are thrown off from luminous stars, or from fine cosmic material near the stars, being driven away by the pressure of light, are not necessarily of dimensions much larger than molecular, and although the swiftness and small mass of such light-repelled particles must prevent them from acquiring additions by attracting the atoms near which they pass, some increase of size is to be anticipated by chance collisions with atoms, the particles being slowed down and reabsorbed by massive attracting bodies. But these are the last steps of an intergalactic process. We must go farther back to reach its inception.

If we attribute the absorption of light in space to the ether itself,

the radiant energy absorbed performs work upon the ether, presumably the generation of minute ethereal vortex-rings—the elementary particles from which electrons are derived, or possibly the positive and negative electrons themselves out of which the atoms are formed. From associations of electrons to atoms, from atoms to molecules, from molecules to the first tiny beginnings of a cosmical crystalline sublimate, there is a continual progression and increase of size. Finally, this widely dispersed material must be gathered from the immense voids of space into the germs of future worlds, and for this task the meteorites appear to be the appointed instruments.

A process which goes on forever in one direction is inconceivable. For every swing of the pendulum there must be a counter swing. If atoms have been built up by the action of light, they can be torn apart, and the energy of their formation will be once more set free. We may assume that a certain proportion of the atoms disintegrate, a very minute proportion ordinarily in planetary bodies, but a much larger one under solar conditions. The following facts suggest a relation: (1) The known radioactive elements disintegrate with the production of helium, and the evolution of enormous thermal energy. (2) The stars which are, at least externally, the hottest, since they have effective temperatures which have been rated in a few cases as high as 40,000° C., are surrounded by extensive atmospheres of helium. These relations favor the hypothesis that the helium stars contain an exceptional amount of peculiarly unstable elements, and owe their high temperature to the heat set free in the gradual elimination and destruction of these substances. The energy of formation of the atoms is being slowly dissipated as radiation from the stars, but is eventually reabsorbed by the ether, and is thus restored to the material phase of its existence by the formation of new atoms.

A plausible inference may be formed from the behavior of radium. In 1,000 years, 4 grams of radium will have been nearly one third transformed into other forms of matter of less intrinsic energy, the radium being reduced to about 2.8 grams. During this interval of time, the four grams of radium will have emitted, according to Rutherford's measurement of the annual production of heat from radium,

$$\frac{(4.0 + 2.8)}{2} \times 876{,}000 \times 1{,}000 = 3.0 \times (10)^9$$

gram-calories of heat. This is, of course, only a first approximation. The progression is not strictly linear. Since the gram of substance transformed has not, in this case, been annihilated as matter, but has simply been transmuted into other forms of matter, the $3 \times (10)^9$ gram-calories of thermal energy do not represent the total mass-energy of the gram of matter, but only that portion of the mass-energy which has been lost in this partial transformation. If we suppose that the total original energy is 1,000 times as much as that which has been lost

in 1,000 years by radio-active transformation, or enough to last at the same rate for 1,000,000 years, the thermal energy corresponding to the mass-energy of one gram is $3 \times (10)^{12}$, which is very nearly the same as the $5 \times (10)^{12}$ water-units, computed by De Volson Wood for the specific heat of the ether.[13] We seem, at any rate, to be approaching limiting values which are perhaps connected with the transition from ether to matter, or the reverse. If a volume of rotating ether, having a specific heat of $5 \times (10)^{12}$, can be condensed, or in any other way transformed into a volume of matter with specific heat unity, since specific heat is capacity for absorbing thermal energy, the tremendous shrinkage of this capacity during the formation of matter out of ether represents the absorption of so much energy, and the almost complete saturation of the original capacity. It follows that if the process is reversed, the thermal energy of atomic formation must be set free.

Since radium decays far more rapidly than most elements, the one million years suggested in the preceding illustration must be greatly extended in order to represent the average duration of matter. Similarly, the one million light-years deduced for the distance of the fainter nebulæ on the Lick Observatory plates is not a limiting distance beyond which light can not penetrate, but it is a distance at which light is reduced to perhaps eight per cent. of its original intensity, or a quantity of that order. It is evident from the phenomena connected with the decay of the radio-active elements, that different elements have different durations. The rarer elements are either those which require a very long time and a long process of successive ethereal modifications in their development, or else they are elements which are relatively unstable, and which decay more rapidly than the others.

Rutherford gives the radius of an electron as $1.4 \times (10)^{-13}$ cm., on the supposition that the electron is a sphere, in which case its surface will be $2.5 \times (10)^{-25}$ sq. cm., and its volume $1.1 \times (10)^{-38}$ cub. cm. The mass of an electron being, according to Sir J. J. Thomson, 1/1700 times that of a hydrogen atom, and the latter weighing $1.1 \times (10)^{-24}$ gram, the density of an electron works out

$$D = \left(\frac{1.1 \times 10^{-24}}{1.7 \times 10^{3}}\right) \div (1.1 \times 10^{-38}) = 5.9 \times 10^{10} \text{ (water} = 1).$$

This value is so extraordinary that obviously we are not dealing with any ordinary problem in material density. The only phenomenon which has any resemblance to it is the increment of mass which the electron acquires at velocities approaching that of light in Kaufmann's experiment. Add to this the fact that the velocity of light is a constant, and the conclusion apparently follows that if the velocity of wave-motion in the ether can be diminished to even the smallest extent below that of light, the medium ceases to be ether, and the motion ceases to be ethereal wave-motion, but is left behind as the beginning

[13] *Philosophical Magazine* for November, 1885, pp. 402–403.

of a materialized etheric energy. The enormous density found for the electron is an average density and must be still more exceeded if the mass-giving energy is not distributed uniformly within the volume. By all electric analogies it is natural to assume a superficial concentration of energy in the electron itself. The large apparent density of the electron is perhaps explicable on the assumption that the mass-giving substance is condensed in a very thin surface-layer where it revolves with a velocity smaller than that of light by only a very minute amount. The substance of such a shell should have an almost infinite density. The average density of the enclosed volume should still be very great. If, for example, the electron is a vortex-ring of ether of the same surface as the sphere, an almost infinitesimally thin shell of ether revolving ever so little slower than the velocity of light, is no longer free ether, but becomes matter of almost infinite density, the velocity-gradient falling off very rapidly in the interior of the vortex, and the internal density being negligible. Such a body should possess surface potential, polarity, strong elastic resistance, and other properties demanded of the electron.

If it be admitted that a definite volume of ether can receive a permanent limit, it seems necessary that some surface of discontinuity, as well as a stress, akin to fluid viscosity, exerted between the volume and its surface, should be set up. Calling E the ethereal viscosity, A the surface of discontinuity, and V a velocity, such as the mean velocity in the volume, or the limiting velocity at the surface, to be determined by the nature of the viscous mechanism which is at present unknown, the viscous stress (F), so far as it depends on dynamic considerations, is equal to a momentum transferred through a definite volume of fluid to a limiting surface at a given speed, and may be represented as in fluid viscosity by the equation

$$F = EAV,$$

but with this distinction: The ether has no mass except as it acquires mass by receiving a rotary motion. The dimensional equation for viscosity,

$$E = M/LT,$$

becomes

$$E = L^3 \times \frac{L^2}{T^2} \times \frac{1}{LT} = \frac{L^4}{T^3},$$

since the etheral mass is proportional to the energy (which varies as the square of the velocity) impressed upon a volume proportional to r^3, where r is the mean radius of the gyrating volume. In the case of a ring rotating in its own plane, or of a surface rotating around an axis which is a closed curve, r may be the radius of the ring or of the surface. Substituting the value of E in the expression for F, we have

$$F = \frac{L^4}{T^3} \times L^2 \times \frac{L}{T} = L^3 \times \frac{L^4}{T^4},$$

$$F \propto r^3 \times v^4.$$

The ethereal viscosity being excessively small, either very high velocities, or very long durations are required to produce appreciable ether drift. As Lagrange has demonstrated, there can be no surface of discontinuity in a perfect fluid, because such a surface implies a continuous generation of rotation in portions of a fluid of constant density. Conversely, if any discontinuity can be imposed upon the ether, it must be a viscous fluid. Any structures formed from a viscous fluid must eventually decay. The duration of the material phase may be enormous, but its ultimate transition is inevitable. The point I wish to make is that there is evidence of an absorption of light by the ether, and that there is also evidence of atomic disintegration. The two processes interlock into necessary and concomitant parts of a consistent whole. What I have tried to demonstrate is the existence of a phenomenon and its approximate law, without attempting a refinement which would be unwarranted at the present stage of the investigation.

Conclusion

In brief, we may conclude that space contains myriads of galaxies which would make the midnight sky one blaze of light, were it not for the absorption of light by the ether of space. This absorption can not be a selective scattering by gaseous molecules, because this would deplete the radiation of short wave-length unduly, and would redden the light of the more distant nebulæ, whereas no such change of color with distance is found. Neither can the absorption be due to the general absorption of radiation of every wave-length by coarser meteoritic dust, since the meteoritic material would in time become heated to incandescence, as Arrhenius has noted, and in this case also the entire heavens must glow. There remains, then, the supposition that the ether itself absorbs the radiation from the stars, and that in this fixation of energy, matter originates.[14]

There is, I apprehend, a close analogy between the sequences of cosmogony and of geogeny. Upon the earth there are wide expanses of oceanic depths which have apparently remained such from the beginning of denudation. That remarkable property of saline solutions whereby suspended solid particles are quickly precipitated, causes the marginal deposition of those sediments brought to the sea by the rivers. The oceanic depths are the counterparts of the intergalactic spaces. In both, change progresses very slowly.

But around the borders of the continents, sediments accumulate in geosynclines which are self perpetuating. The increasing weight of the deposit deepens the depression, until after the accumulation has

[14] As suggested in my paper, "A Cosmic Cycle," *Am. Jour. Sci.*, Ser. 4, Vol. 13, p. 189, March, 1902.

reached a depth of 10 to 15 kilometers a reaction sets in. The deeply buried beds of water-bearing detrital formations soften, very likely under the influence of heat generated by the concentrated radioactive minerals, as Professor Joly supposes.[15] Long eras of crumpling, elevation and mountain-formation follow, to be in turn succeeded by other ages of denudation. "The energy which determines the place of yielding and upheaval, and ordains that the mountains shall stand around the continental border," passes through a rhythmic interchange or cycle. The cosmogonical process which I have described embodies an analogous cycle, embracing the formation of matter from the ether, and most abundantly in the vicinity of stellar aggregates, by the fixation of the radiant energy, outpouring from the disintegrating stellar substance. Then follow, in turn, the concentration of the material on the borders of the earlier galaxies and the birth of new heavens. In proof of this association of old and new along a border region, the similar distribution of the fourth-type and helium stars, which probably represent the extremes of a thermal series, may be cited.

The conception of a universal ether is to many so vague that the distinction between ether and a purely spiritual atmosphere seems slight; yet the difference is fundamental. The mind of man is not conditioned by space. Thought can not be measured by the yardstick. Ether, on the contrary, occupies space. The dimensions of its waves have been made the fundamental standards of our units of length. Nevertheless, we still grope and guess as to the real structure and nature of the ether. Some of its properties seem to verge on the metaphysical. Back of it, we have glimpses of a source of energy which is inexhaustible, as if it were most intimately linked with the Infinite Source of all existence. Matter which used to be looked upon as dead, and as incapable of exhibiting energy except as this was thrust upon it from without by physical forces, begins to look almost alive. "It moves," said Galileo, of the solid earth; and to-day the delighted physicist, armed with the spectroscope and spinthariscope, Crookes's tube and the electrometer, finds, in the Zeeman effect or the radium emanation, evidence that the atom is an orderly maze of bewildering motion. Its inertia is a gyroscopic inertia. Absolute rest would be nonentity. Everywhere the universe speaks of never-ending life and motion. Creation is not the bringing forth of an infinite number of dead structureless particles, sent out as a set of miserable little waifs at some indefinitely remote epoch and left to clash without guidance, without purpose. Creation is perpetual. The interiors of matter are seen to be more and more wonderful, more and more intensely active, as we approach the sacred portals where divine influx from the Soul of the Universe quickens into the energy which is matter.

[15] J. Joly, "Radioactivity and Geology. An Account of the Influence of Radioactive Energy on Terrestrial History."

THE PROGRESS OF SCIENCE

THE ACADEMIC SITUATION.

SCARCELY a month passes without the occurrence of one or more events disquieting to those who would make our universities the homes of scientific research, creative scholarship and social progress. Such circumstances do not usually become known, for it is to the private advantage of those concerned that they be hushed. Strange as it may seem at first sight, the state universities are on the whole making progress in the direction of greater academic freedom and dignity, while the private corporations tend to exhibit the reactionary tendencies of their boards and administrative officers. If, however, the people learn the importance to the nation of maintaining their universities on a high plane, all is well. It is easy to tax corporations which become antisocial into innocuousness. Indeed each university will find its own level by its own weight. Harvard and Columbia are still our richest institutions and probably still maintain their leadership in advanced work and public service; but they are losing ground relatively to the state universities and perhaps even in comparison with their own positions ten years ago. It would surprise most people to see the list of those who have recently declined to consider chairs at these two universities.

It is the high traditions of Harvard which give significance to the curious circular recently sent from the controller's office to those whom one university president habitually calls "the instructional force." The circular is accompanied by four large pages of instructions and a schedule containing some 180 blank spaces to be filled and is couched in jargon about "prorating salaries to the various classified functions," and the like. The professors and instructors are informed that

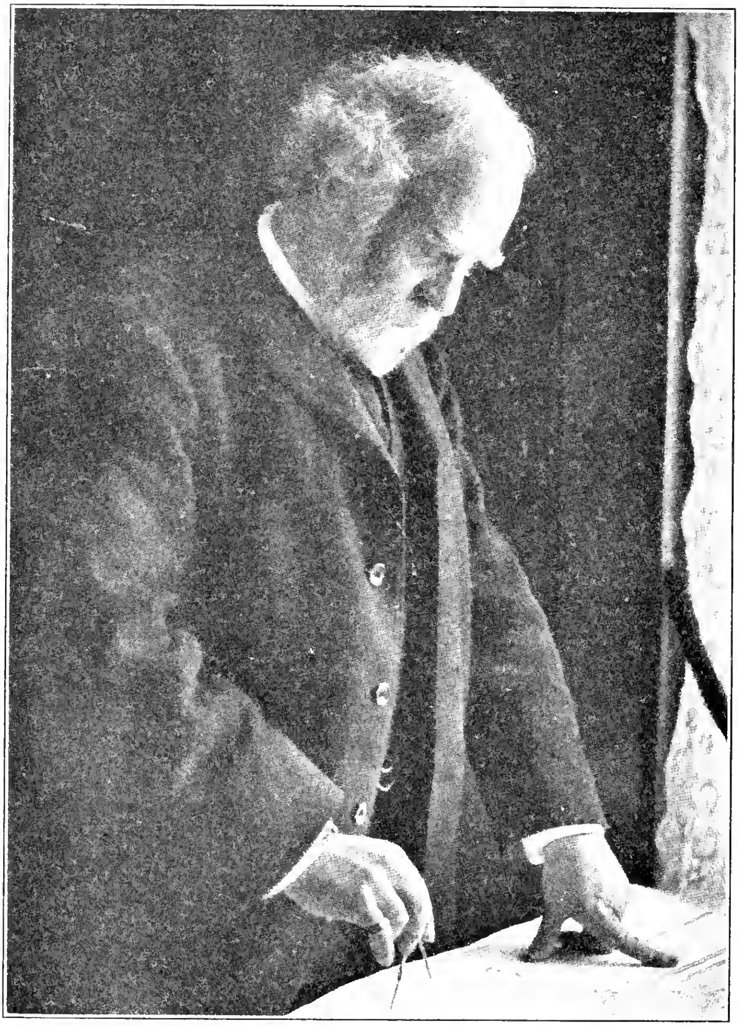
$(2a \times 3a) + (2b \times 3b) + (2c \times 3c) + (2d \times 3d) + (2e \times 3e) =$ total hours of regular exercises per course.

They are told that

> Preparation for lectures should include only that time which was taken during the half-year for lectures delivered in this period. It should not include time spent in the general collection of materials.

Surely the only correct answer to the question how many hours a day a professor spends on his work and in preparation is twenty-four. This circular was naturally resented by members of the faculty and was partially, but somewhat grudgingly, withdrawn, the president stating that it was "issued under a misunderstanding," presumably a misunderstanding of the sentiments of the faculty.

This Harvard incident is serio-comic. At Wesleyan there has occurred within the same past month a wholly serious breach of academic decency. The professor of economics and social science, who has served the university and the public with distinction for twenty years, made some remarks in regard to the observance of the sabbath, which found their way into the newspapers. The president wrote inquiring whether he was correctly reported, and on being told what he had said, asked for his resignation. This was promptly sent, and the president relieved him from his duties at once. The five letters passed in the same day, and the president must have acted without adequate consultation or consideration. It is as extraordinary as it is ominous that in our present academic system the liberty of speech of a professor and the fate of his wife and children should be dependent on the will of an official. In this case the professor was speaking within his own professional field, and not even to students of the university



Sir John Murray.

or in its city. He surely would fare ill at Wesleyan University who said "The sabbath was made for man, and not man for the sabbath" and "Beware of the scribes which . . . for a pretence make long prayers; these shall receive greater damnation." The trustees of Wesleyan University still have the opportunity to decline to accept the resignation of the professor of economics and social science. The other honorable alternative is to change the name of the institution to the "Middletown Methodist College."

THE DEPTHS OF THE OCEAN

Oceanography as a science may be dated from the voyage of the *Challenger* round the world from 1872 to 1876 under the scientific direction of Sir Wyville Thomson and the naval command of Sir George Nares. Sir John Murray was one of the naturalists of the expedition and later became editor of the great series of reports. In addition he has published many important papers on oceanography and marine biology and has conducted surveys in marine and inland Scottish waters. Probably Sir John Murray and Alexander Agassiz are the two men who have accomplished the most for marine biology, and it is a cause for pride that both were born on this side of the Atlantic. We may also view with gratification the earlier work of Bache of our coast survey and of Maury of our navy, who in the forties and fifties laid the foundation on which the science of oceanography has been erected. When Sir John Murray visited the United States last year and made a series of extremely interesting addresses in various places, he established a fund in honor of Alexander Agassiz, under the National Academy of Sciences, for a medal to be conferred for distinction in oceanographic research. It should give us pause to reflect that there is none so well deserving this medal as were Dana, Bache, Maury and Agassiz.

In 1909 Sir John Murray—who like Agassiz acquired wealth by an incidental use of his scientific observations—offered to defray the expenses of a cruise of the *Michael Sars* in the North Atlantic, if the Norwegian government would lend the ship and its scientific staff. The expedition was undertaken with the cooperation of Dr. Johan Hjort, director of Norwegian fisheries. The *Michael Sars*, named in honor of the naturalist who sixty years ago made dredgings off the coast of Norway, was admirably equipped for deep-sea explorations. Starting from the east of Ireland it worked down to the Canaries and by way of the Azores to New Trinidad and back to Ireland and Bergen. About 120 observing stations were established and much valuable information was obtained, while the biological material has been distributed to specialists in different parts of the world.

A general account of the researches undertaken by the *Michael Sars* and of the modern science of oceanography has now been prepared by Sir John Murray and Dr. Hjort and has been published by The Macmillan Company. The book contains some 600 illustrations, the portrait of Sir John Murray being here reproduced, and forms an accurate and readable account of what is known in regard to the depths of the oceans of the earth.

GEORGE HOWARD DARWIN

Sir George Darwin, of whose death we learned not long ago, was, perhaps as much as any of our times, one of the most noteworthy examples of the best scientific lives of our generation. Sprung from a family with notable scientific traditions for several generations, and gifted with talents in no way inferior to the best of those amongst whom he worked, he employed all the resources at his command for the promotion of the highest interests both of his own subject and of the

Sir George Darwin.

scientific world at large. Never very robust in health, he accomplished several long and laborious tasks and yet rarely failed to place his time and energy at the disposal of those who made demands on them. He was brought up in a school of mathematics which put ingenuity and brevity at a high premium, yet when faced with a difficult problem he usually chose the direct route towards the solution, often at the cost of long and laborious calculations. Even when deeply engrossed in the work he was doing, he would lay it aside at a moment's notice to listen to and discuss the problems of his friends or pupils. And while acting as an inspiration to many of his contemporaries, he never failed to impress them with his modesty even when expressing his own opinion in his direct but kindly manner.

For many years Sir George Darwin has been recognized as the leader—a title he would have immediately disclaimed—in a subject which is perhaps the most fascinating and the most dangerous of all those which may occupy the thoughts of a scholar. Cosmogony is replete with unsolved problems and hypotheses may be multiplied almost indefinitely. Almost any new discovery or advance in our knowledge of the physical world may have a bearing on it. Sir George Darwin, whose best known work lies in this field, never allowed himself to be led much beyond what he was able to establish by exact methods. If he gave a theory of the past history of the earth and its satellite, he did not allow the reader to imagine that he had solved the problem, but simply considered his work as sufficient to make probable a possible hypothesis.

While his earlier interests were in the direction of pure science, his association with Lord Kelvin led him to the consideration of a practical problem. Tidal prediction is always important for a country with the mercantile interests of Great Britain. Sir George Darwin had immense power in dealing with long and intricate calculations, and his ability was nowhere better employed when he drew order out of chaos in furnishing methods which could be used by a seaman to obtain the tides of his port of call or by a government in the formation of tide tables for its coasts. This same facility and his gathered experience led to his advice being continuously sought in the discussion of meteorological records. In geodetic problems he was one of the chief advisers of the government and was its representative in the international congresses which have been held in Europe during the last fifteen years. In all such matters the English government asks for and acts upon the opinions of its representative scientific men, and Sir George Darwin took his full share in these responsibilities.

His most notable public function was his presidency of the British Association during the memorable tour in South Africa some seven years ago. The sounds of the warfare in that country had only just ceased and great tact was needed to avoid any unpleasant feelings either amongst the native or white races. It is not too much to say that the association could hardly have made a better choice for its presiding officer. In some forty speeches all over the colonies, while avoiding platitudes, he hit the right note, not stirring up excitement and not sending his hearers away without some thought which characterized the occasion. The same touch was visible in his final public appearance as president of the Mathematical Congress held in Cambridge last August. None of those who heard his tribute to Henri Poincaré on that occasion realized that he himself would so soon also depart.

His numerous friends not only in England and Europe, but also in this country, will regret the passing, not alone of the student, but of the wise and kindly man whose humanity was never lost in his scholarship.

SCIENTIFIC ITEMS

We record with regret the deaths of Mr. Francis Blake, inventor of the telephone transmitter and other electrical apparatus; of Dr. Thomas Volney Munson, who while engaged as a nurseryman at Dennison, Texas, made valuable experiments on the breeding of fruits, especially in viticulture; of Professor George Augustus Koenig, professor of chemistry at the Michigan College of Mines; of M. Louis Paul Cailletet, the distinguished French chemist, known especially for his work on liquefaction of gases; of M. Léon Teisserenc de Bort, the French meteorologist, known for his work with captive balloons; of Dr. Otto Schoetensack, professor of anthropology at Heidelberg, and of Dr. Yujiro Motora, professor of psychology at Tokyo.

The Elisha Kent Kane gold medal of the Geographical Society of Philadelphia was presented to Professor William Morris Davis, of Harvard University, on January 28, and the Culver medal of the Geographic Society of Chicago, on February 19.—Professor George Herbert Palmer, Alvord professor of natural religion, moral philosophy and civil polity, and Professor Francis Peabody, Plummer professor of Christian morals, have given their final lectures at Harvard University. Professor Palmer has served the university for forty-three years and Professor Peabody for thirty-eight years. —Professor J. Hadamard, professor of analytical and celestial mechanics in the Collège de France, has been elected a member of the Paris Académie des Sciences in the section of geometry, in succession to the late Professor Henri Poincaré.

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THE INFLUENCE OF FORESTS UPON CLIMATE

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Introduction: Popular Belief in Forest Influences, and its Possible Origin

FAR and wide, the world over, we find a popular belief in an influence of forests upon climate, especially upon rainfall. This is not difficult to explain. Take our own experience, for example. On a summer day we leave the hot, sunny road and walk along a narrow forest path. The trees give shade; the glare and heat of the road are replaced by the soft, dark carpet of leaves and moss; the air seems cool and damp. It is all a great relief, and the impression is inevitable that a forest climate is different from that of the open. Again, on a spring day, when the snow has disappeared from the fields, but when a chilly, wintry wind is blowing, we leave the open meadow and cross a patch of woodland. There is snow still lying deep under the trees; there is welcome protection from the biting wind; it seems pleasantly warm. Has not, we naturally say, the forest a climate all of its own? Once more. We observe, the world over, that where there are extended forests there is heavy rainfall, and we see deserts and treeless areas where the rainfall is light. We infer that the forests have something to do with producing the heavier rainfall, and some of us may even go a step farther and think that the great treeless areas were once forested, and that deforestation has made them dry. Or, to give one more case, we may have noticed the increasing tree-growth with increasing elevation on our mountains, and may have concluded that the denser forest is the cause of the heavier precipitation which is generally observable as we ascend our mountain slopes.

Thus it may come about, naturally enough, that people believe in forest influences upon climate. Yet, if we ourselves happen to have

based our own belief on any such evidence as the foregoing, we ought to remember that our own sensation of heat, or cold, or dampness, by no means necessarily, or even usually, corresponds with the actual meteorological facts. Further, the great rainy and dry belts of the earth's surface are controlled by a world-wide distribution of temperature, pressure and winds, that is, by the general circulation of the atmosphere, and by conditions of the higher strata far and away beyond the reach of any local effects such as those of a forest. Universally, in response to natural controls, a scanty rainfall is hostile to tree-growth, and forests are favored by heavy rainfall, which gives good conditions of soil-moisture and is generally accompanied by higher relative humidity, more cloudiness and less extreme temperatures than prevail over treeless regions. In the case of mountains, again, it should be clearly in our minds that, as a rule, and up to a certain limit, an increase of altitude involves an increase of precipitation, quite apart from the presence or absence of any forest. We must be careful not to put the cart before the horse. The forests, in other words, are the result of the rainfall, and not *vice versa*.

Importance of the Subject: its Complexity

That this subject has an important relation to our national conservation policy no one will deny. Unfortunately, the discussion of it has become more or less a matter of semi-political controversy. Much has been written without adequate study of the question. Heated arguments, *pro* and *con*, have been advanced in debates and in print. Remarkably divergent views have been, and are to-day, held upon the question. It has been claimed that forests have no climatic influences whatever. On the other hand, some have believed that deforestation in North America has affected the climate of Europe. A recent writer maintains that the principal cause of the "intellectual and industrial stagnation" of the Spanish peasants is to be found in the effects of deforestation in making the climate drier, so that the people are "worked to death to support life." The literature is extended and bewildering. It runs back at least five hundred years. A bibliography published in 1872 contains nearly two hundred titles, and began with Fernando Columbus, who attributed the heavy rainfall of Jamaica to its heavy forests, and a (supposed) decrease of rainfall on the Azores and Canaries to deforestation. It has been said that this whole discussion first came up in really acute form at the time of the French Revolution, when private timberlands were largely destroyed.

The subject is thus greatly complicated by the nature of the discussion. It is, furthermore, by its very nature a complicated problem. On the one hand, climate itself is the complex resultant of many different controls. Among these are the latitude; the elevation above sea-level; the varying influences of land and water; the proximity of ocean currents; the prevailing winds and storms. In this list of controls, but at

the end, the last and the least important of all, modifying slightly, perhaps, the total effect of all the other controls, comes the surface-covering of the earth. This may be snow, or grass, or sand, or lava. Here belongs the forest, a special kind of surface covering.

On the other hand, the forests. What do we mean by forests? Do we mean the vast, dense tropical forests of the Amazon, or a grove of trees on a New England farm? Have we in mind evergreen or deciduous trees, or both? Are the forest trees tall or scrubby? Is their height uniform or varying? Is there undergrowth or is the forest clean? Are we considering the forested slope of a steep and lofty mountain or the trees in a valley bottom; a tropical or an extra-tropical forest; a region of heavy or one of moderate rainfall; of much or of little cloud? Clearly, a complex problem is here before us. No wonder that so much diversity of opinion exists with regard to it. Few of those who discuss the question are at all aware of its extent or complexity. They see only one or two small aspects of it, and upon a very insufficient, and often inaccurate, knowledge they base broad and misleading generalizations.

In a matter of such general interest it is most important to proceed carefully, and to see clearly just what we do, and what we do not *know*. That is the purpose of the present paper: to set forth, as the writer sees it, the status of the "forest and climate" discussion in the light of the available *facts*. It may be added, parenthetically, that it is only comparatively recently that a scientific study of the subject has been possible.

The Historical Method of Treatment: its Unreliable Results

The favorite method of attacking the problem of forest influences has been the historical method. Probably the large majority of those who believe in such influences are affected, consciously or unconsciously, by the use of historical arguments. A certain region, we hear, was once forested. There are now few or no traces. "People" say that the climate there has "changed." Hence, the disappearance of the forests must have produced the change of climate. This is not an unfair illustration of the historical argument. Sometimes, of course, simple hearsay, and general impressions, are replaced by actual records of the change in area covered by trees, and by rainfall observations (extending over a relatively short period), or by rough accounts of the depth of water in rivers and streams. But, at best, this method of treatment is very unreliable. All the elements in the discussion are uncertain: the early forest conditions; the supposed "change" of climate; the accuracy of any available meteorological observations. Granted that a "change" of climate has actually taken place, was the so-called "change" the cause, or the effect, of the change in forest cover? And may not the "change" have been the result of the well-known oscillations of the climatic pendulum, which bring periods of wetter and then

of drier years, and which are, therefore, more, or less, favorable to forest growth?

The historical argument may be illustrated by the following:

> The valley of Aragua, in Venezuela, is shut in on all sides, and the rivers which water it, having no outlet to the sea, unite and form Lake Tacarigua. This lake during the last thirty years of the past century showed a gradual drying up, for which no cause could be assigned. In the beginning of the present century the valley became the theater of deadly feuds during the war of independence, which lasted twenty-two years. During that time land remained uncultivated, and forests, which grow so rapidly in the tropics, soon covered a great part of the country. In 1822 Boussingault observed that the waters of the lake had risen, and that much land formerly cultivated was at that time under water. The drying up of the river Scamander in the Troad, and the contracting of the Euphrates in its channel, may be referred to as illustrations of the same effect of the cutting down of forests, and of diminished vegetation. (Buchan's "Introductory Text-book of Meteorology," 1871, p. 50.)

Clearly, we have nothing beyond the merest hearsay evidence in all this, and absolutely no facts upon which to base a scientific conclusion.

Again, in regard to Greece:

> In the course of centuries, the forests have in large measure been destroyed . . . and with the passing of the trees the rainfall has decreased, so that during the summer months, when hardly a shower comes to moisten the parched earth, the country is for the most part extremely arid. (Clarence H. Young, *Bulletin American Geographical Society*, Vol. 32, 1900, p. 151.)

Those with even an elementary knowledge of the climatic zones will recall that Greece, like northern California and northern Africa, lies in the subtropical belt, whose dry, or even wholly rainless summers, depend upon the great controls of temperature and pressure and winds and storm-tracks, far and away beyond the reach of any such insignificant local agencies as a few trees.

Or again:

> The rainfall (of Teheran) was formerly very much less, say up to 10 or 11 years ago; it then did not, I think, exceed five inches per annum, but it is now about ten. The great increase is no doubt due to the many gardens which have sprung up within the last 10 years in and outside the city, and perhaps also to the formation, 10 years ago, of a lake 50 miles south of Teheran. The lake has a length of 22 miles, and is from 3 to 6 miles broad. (A. Hontum Schwindler, *Symons's Monthly Meteorological Magazine,* Vol. 28, 1893, p. 145.)

This is a good example of the weakness of the historical argument, even when apparently based upon actual observations.

We might cite further the rather hackneyed examples from Trinidad, where the cause of a general but rather slight decrease in the mean annual rainfall for ten-year periods between 1862 and 1891 (from between 66.50 and 67 inches at the beginning of the period to slightly over 65 inches at the end) has been "said to be the disappearance of the forests"; from Kimberley, where the cutting down of trees to supply timbers for the mines is supposed to have had "most injurious effects on the climate," increasing the number of dust-storms, among other effects; from Ismailia, where tree-growth since the opening of the

Suez Canal is said to have brought an increased rainfall; from the Peninsula of Sinai, from Syria and from Algeria, in all of which deforestation is said to have changed luxuriant and fertile districts into deserts. One other example, quoted by a recent writer, may, perhaps, be referred to:

> In 1551 the Marquis of Northampton went from Orleans to Nantes (on the river Loire), with his suite, in "five large, many-cabined boats," whereas navigation is now impossible above Saumur, the distance of which from Nantes is less than half that of Orleans. This change is ascribed to the deforestation carried on extensively in the surrounding country in the seventeenth century, and the consequent diminution in the volume of water in the Loire due to diminished rainfall.

There is no need to multiply these examples. They show, clearly enough, why the historical method is unsafe, and why it has given but meager results.

An Essential Consideration: Why Should Forests Influence Climate?

It is a curious fact that so few of those who are firmly convinced that climate is affected by forests, ever seem to ask themselves: "Why *should* forests influence climate?" We seem to accept it as a fact without asking ourselves why it should be so. If we stop a moment to consider the reasons which come to mind, we shall probably sooner or later enumerate them about as follows:

(*a*) Because forests must retard and obstruct air movement, favoring calms, and causing the air to ascend slightly over the trees. Both of these effects may be favorable, in a small way, to rainfall. The barrier effect, by reducing the velocity of high winds, ought to moderate the extremes of winter cold.

(*b*) By means of their shade, trees ought to check the warming of the ground, and of the air, especially in summer.

(*c*) Because of the retention of moisture in the forest litter, and of the decreased evaporation which may be expected to result from the lessened air movement under the trees, it seems not unreasonable to expect that forest air will be somewhat damper than that outside. This, under proper conditions, may also favor rainfall.

(*d*) The diffusion of the water vapor transpired by and evaporated from the leaves may perhaps increase the opportunity for rainfall.

(*e*) We may expect the tree cover to diminish nocturnal radiation from the ground underneath, and thus to maintain a slightly higher temperature within the forest than outside of it at night.

(*f*) Also, there may be some effect from the increased radiating surface due to the presence of the leaves or needles. This must be chiefly effective at night.

(*g*) The heating of the leaves must be less than that of bare ground, because of the evaporation of much water from the leaves, and because

of the slow heating of the water in the leaves. To a certain slight extent, then, a forest cover ought to behave as does a water surface; it ought to warm a little less rapidly and therefore it ought to cool less rapidly.

(*h*) The process of growth of the trees, and the chemical changes which are going on during their life, must require an expenditure of energy whose effect might possibly be observable in a difference of temperature between the forest and the open. The rise and return of the sap may also be expected to be accompanied by certain slight temperature effects resulting from the transfer of root temperatures upwards and of crown temperatures downwards.

In these, and perhaps in other ways, we may seek for the causes of forest influences upon climate. But, whatever may be the theoretical reasons for believing in such influences, we are here concerned only with the facts as they are at present known. One further word of caution is necessary. It is one thing for a forest to have a climate of its own within its own limits, under or above the trees. It is quite another thing for a forest to affect the climate of the surrounding country, or of distant regions. The latter effect is naturally the one in which the real interest centers. But it is also the one which is by far the most difficult to study. It is clear that nothing more than reasonably local modifications of climate ought to be expected. The special climate of the forest itself—so far as it may appear to have one—can only affect the surroundings by modifying the air currents which pass through or over it, by producing an ascending movement of the forest air to take part in the prevailing wind movement, or by causing, as may happen under especially favorable conditions, local air currents of its own. Most, if not all, of the above-mentioned theoretical effects of forests upon climate have been overestimated.

Forests as Wind-breaks

The most obvious effect of forests is that of the barrier, or wind-break. First, there is far less wind movement within the forest than there is outside. Second, friction on the tree-tops reduces the velocity of the wind blowing over the forest. Third, to leeward of the forest there is a belt of relative calm which is roughly ten to fifteen times as wide as the forest is high, as has been determined by measurements in Iowa and in the Rhone Valley. More recently, in Roumania, Murat has shown that within 165 feet to leeward the decrease in velocity may be from four to eight miles an hour, and that the effect of the forest in decreasing velocity extends as far as 1,500 feet to leeward. Some years ago, comparative observations in the harbor, city and suburbs of New York and Boston showed a remarkable reduction in wind velocities with increasing distance inland, the velocities in the city being a little over three fifths, and those in the suburbs about one third, of those in the harbor.

Clearly, then, wind-breaks such as those which have been recommended for, and are found in, much of our western treeless area furnish considerable protection, over a narrow strip to leeward of the trees, against the sweep of strong hot or cold winds. Such a reduction in wind-velocity may have beneficial effects in reducing somewhat the extremes of heat or cold, and in diminishing evaporation from soil and from plants, and perhaps also in checking the blowing away of the soil. On the other hand, frost is more likely to occur where there is less air movement. Deforestation, on a large scale, especially on extended level areas, will therefore favor a freer sweep of the wind, which may be hostile to the growth of crops. Over any extended treeless area, exposed to high winds and with a severe climate, the best protection will be found in the planting of narrow belts of trees, alternating with agricultural strips. It should be noted, however, that this very wind-break, by decreasing wind velocity, keeps the air of the forest interior from affecting the atmospheric conditions round about. In other words, the forest diminishes its own climatic influence.

Influence of Forests upon Temperature

There is comparatively little popular interest in any possible influence of forests upon temperature, attention being almost altogether focused on the rainfall factor. Upon their soil temperatures, forests have a slight cooling effect (up to about 5°) attributable to the shade and to the greater moisture of the forest floor: the extremes are retarded and reduced; frost penetrates less deeply. Between evergreen and deciduous forests there is this difference, that in the former sunshine has freer access to the ground, and warms and dries it better than in the latter. In general, a forest climate bears a faint resemblance to a marine climate in having a slightly smaller range of temperature than the open, the extremes being most moderated in summer. In central Europe the mean annual minima are about 2° higher in the forest, and the mean annual maxima are about 4° lower. Individual summer maxima may be 6° to 8° lower in the forest, and individual winter minima 3° higher (Prussia). Conditions in the United States are probably not very different, although our greater extremes of heat and cold here would perhaps lead us to expect a slightly greater forest effect in moderating these extremes. The sum-total effect is, therefore, a slightly cooling one, chiefly because the forest is a little cooler than the open in summer, and about the same, or very slightly warmer, in winter. But these temperature differences in the average of the year are very small, and even in individual cases are certainly usually inappreciable without the use of thermometers. The considerable difference in our feelings of heat and cold ("sensible temperature") within and outside of a forest is probably chiefly due to the combination of the other factors, such as wind movement, moisture, exposure to sunshine, etc. Indeed, a good many of the reported differences between field and forest are probably

too large, owing to unfavorable exposure of the thermometers. It is, however, significant that the presence of relatively cool air over forests has been indicated by the fact that balloons, in passing over forested sections, often have a distinct tendency to descend. This cooling effect above the forest is pretty clearly of more importance than any temperature effect within the forest, but we have as yet very little reliable information on this phase of our problem.

It is to be expected that equatorial forests should have more marked effects in lowering the temperature than temperate forests. The high maxima reached over the deserts of the lower latitudes, largely as a result of the excessive heating of the sandy surface, do not occur where the dense equatorial forests shade the ground; increase the radiating surface by means of their leaves; supply much water vapor through transpiration and evaporation, and possibly also, by favoring fog and cloud formation, cut off sunshine. Woeikof has done good service in calling attention to this important function of tropical forests. We must not, however, suppose that scattering forest patches in our temperate latitudes can have any notable effects upon temperature. As Supan has well stated the case, in speaking of the very "moderate" effect of forests on temperature:

> No one will care to maintain that the system of isotherms would be radically altered if Europe and Asia were one great forest from ocean to ocean.

Influence of Forests upon Humidity and Evaporation

Within European forests the relative humidity exceeds that over the neighboring glades or fields by a few per cent. (2–10 per cent.). This is an expectable condition, and no doubt in part due to the slightly lower average temperature in the forest. The local formation of dew might be favored on this account. It appears, further, that evergreen forests have more influence in increasing relative humidity than do deciduous forests. Evaporation from free water surfaces within forests is a little less than one half of that in the open, a fact which is to be explained chiefly by the decreased air movement, and, to a much less extent, by the slightly lower temperature and the slightly higher relative humidity. In addition to the action of forests in decreasing evaporation, there is the positive effect of supplying moisture to the air through the process of transpiration. The amount of moisture thus given off from the leaves of the forest has been estimated to vary from three times that from a horizontal water surface of the same extent to less than half that from the water. Evaporation is, of course, much the most active under sunshine. In Central Europe the annual amount of transpiration in forests consisting of well-grown beeches and oaks has been estimated to be about one quarter of the total precipitation.

It is apparent that, as rain-bearing winds progress inland from the ocean, their tendency to continue rainy will be favored if they pass over extended forest areas instead of over bare soil, or even over grass or

crop-covered surfaces. It is also a well-known fact that a certain portion of the rainfall of continental interiors is supplied from secondary sources *not* the ocean, such as lakes, rivers, swamps, and to some slight extent even from the forests themselves. But the forests must of course have received the water before they can give it up; they can not supply it by and through themselves. There seems to be no really very good reason for thinking that the rainfall conditions of the interior of North America would be very much changed if all the forests bordering on the coasts were replaced by crops or by grass. It is foolish for us to think that the forests are more important than the ocean in supplying water vapor for rainfall. Without the rainfall supplied by the vapor evaporated from the oceans the existing forests would never have grown at all. The amounts of moisture concerned in the great rain-producing processes of the atmosphere are so large that the local supply from forests can not conceivably play any considerable part. A recent German writer has stated his opinion that

> It is beyond any question that a forest can not increase the moisture-content of the atmosphere as a whole. On the contrary, it takes from the air a large amount of moisture which has been brought from the ocean by warm ascending currents. Indeed, under certain weather conditions extended forests even favor a decrease of cloudiness by producing a descending current of air, in contrast with the ascending current produced over an easily-warmed open field.

Influence of Forests upon Rainfall: Why do We Expect It?

Thus we come to the phase of the discussion which is of much the greatest popular interest. Do forests increase rainfall? Does deforestation result in a decrease of rainfall? It is almost inevitable that the majority of persons should approach these questions with a fairly strong prejudice on the affirmative side. There is the general and universal impression in favor of such an influence, already referred to in the opening paragraph of this paper. In addition, the theoretical considerations above enumerated turn our thoughts in the same direction. By way of a review, then, let us ask, What are our reasons, at this stage of our discussion, for thinking that forests may influence rainfall? First, the barrier and frictional effect, which, by forcing horizontal air currents to rise, should tend to favor condensation, as cloud, and perhaps also as rainfall. The slackening of the air movement above an extended forest ought to increase the thickness of the stratum of moving air, thus giving it a slight, and local, ascending component. This same slackening effect should produce a tendency to light winds and calms, which are often favorable to showers and local thunderstorms, especially if the air is damp. Second, the damper and slightly cooler air in and over a forest may, at least to a slight extent, affect the passing air currents, especially if these are warm and dry, perhaps increasing the tendency to form local fogs, dew, or even light rain over and to leeward of the forest, provided the existing conditions are already favorable. It has even been held by some that when the

process of condensation has been started, it may continue automatically, the liberation of latent heat tending to produce convectional currents.

This perhaps fairly expresses the general view of the average person at this point. However, having seen that the influence of forests upon temperature and upon humidity is so slight, even among the trees, it is unreasonable to expect that the influence upon rainfall over the forest, and especially away from the forest, will be considerable. In the great ascending, damp air masses of a general storm; in the flow of the winds across a mountain barrier; in the active convectional overturning of a summer thunderstorm—what really significant effect can the slightly damper and slightly cooler air of the forest play in the process of producing or determining the amount of the rainfall? We say, "the air over the forest is damper; therefore there will be more rainfall," quite forgetting that the damper air is useless as a source of precipitation unless it is cooled to the dewpoint. Furthermore, this moisture is constantly being carried away by the winds, and distributed through a great mass of air, thereby giving up more and more of whatever rain-producing effectiveness it may have had.

Forests and Rainfall: the Observations and the Difficulties

Whatever may be our personal prejudices, and whatever may be the theoretical considerations in favor of an influence of forests upon rainfall, what we really want is the facts, so far as they are at present available. Obviously, in a scientific study of this problem, the historical method of treatment, previously referred to; all theoretical considerations, and all prejudices, must give way before the results obtained by means of actual observations, made under approved conditions, with accurate instruments. There has been great difficulty in securing absolutely trustworthy observations. Many of the older records are clearly unreliable because of the improper exposure of the rain-gauges, the differences in the elevation or exposure of the instruments being enough to account for all the observed differences in their catch. Some excellent series of observations have, however, been carried on during the past twenty-five years or more in several European countries, by the agricultural and the forest experiment stations. A system of parallel or radial stations has been extensively used, these being located within forests and in the surrounding open country. Simultaneous observations extending over as many years as possible are compared, the greatest care being taken to have the best exposures, and to allow for the effect of the wind on the catch in the gauges.

The proper exposure of rain-gauges is one of the most perplexing problems in observational meteorology. Rainfall has long been known to be very "patchy," that is, there are considerable differences within very short distances. Thus it happens that gauges which are near together and under similar conditions of exposure often record quite

different amounts of rainfall or of snowfall. Further, the catch of a gauge is markedly influenced by the exposure. In the open field, for example, where there is a free sweep of the winds across the top of the gauge, more rain-drops and especially more snowflakes, are carried over the gauge than in a more protected location, where the drops and flakes can fall more nearly vertically. Thus, a gauge in a forest clearing where the wind velocity is somewhat reduced by the trees, ought to record more precipitation than one in the open country, although the actual fall might be identical in the two cases. A difference of a few feet in the elevation of a gauge will also often result in a catch varying considerably in two neighboring gauges. Furthermore, forests affect wind directions, and this also may influence the catch in the gauges. An element of great uncertainty is thus inherent in all the earlier results obtained by observation, and indeed to some extent in the later ones also, but it should be distinctly emphasized that every effort is now made to "correct" the results for just such errors. In the majority of places where parallel stations exist, the gauges in the forest have actually shown an excess over those in the surrounding open country. Whether this is a real excess of rainfall, or only a difference in the catch, is the disputed point.

The Lintzel Case

There are four cases which have been frequently cited as showing an influence of forests upon rainfall. There is the famous Lintzel case, first cited by Müttrich. At Lintzel, on the Luneburg Heath, in Germany, the rain-gauges used to show a rainfall smaller than the average at a number of the neighboring stations. In 1877 a considerable planting of young trees was undertaken around Lintzel, until several thousand acres were covered. As time went on, the rainfall at the Lintzel station (in an open field surrounded by the forest) showed an increase as compared with that of the surrounding stations.[1] There are, however, reasons against accepting these apparently conclusive results at their face value. The probability of error, the chance of discovering which is greatly diminished by the "smoothing" of the generalized results; the failure to make allowance for the protective effect of the increasing tree-growth; a recent change in the location of the rain-gauge; the shortness of the record, and the general variability and uncertainty of rainfall as a whole, are all considerations which, on the best of authority, may be urged on the other side.

The Nancy Case

Then there is the Nancy case, from France. This is a case of four stations (in two pairs), two in the forest and two in the open, within a small area, the altitudes and the general condition of one pair being,

[1] In 1882–86 Lintzel had about 90 per cent.; in 1887–91 it had about 102 per cent.; in 1892–96, about 118 per cent.

as one writer has said, "as comparable as stations can be made." These Nancy results showed, for a period of about twenty-five years, and for the best pair of stations, somewhat more rainfall (about one half inch to one inch in the yearly average) in the forest. In the case of the other pair the excess was much greater. This series of comparative observations was unfortunately discontinued a few years since, and although the available data have been widely used, they are, in the opinion of the leading official meteorologist of France, as expressed in private correspondence with the present writer, inadequate to serve as the basis of a serious study.

The Indian Case

The two cases just cited are in the temperate zone. The other two cases are found within the tropics. There is, first, the case of a district in the central provinces of India, where forest protection and reforestation began in 1875, and where the rainfall, as compared with the rainfall of all India, showed an increase of about 12 per cent. in a comparatively few years. This, again, seemed an unanswerable argument in favor of a forest influence upon rainfall. But the complication due to periodic oscillations of climate, various uncertainties and the possibilities of error in the observations, together with the difficulty of "correcting" the catch, acknowledged by the Indian authorities themselves, have led to a feeling that we ought at least to suspend judgment in this case. Nevertheless, because the effect of wind upon the rainfall catch is less in the tropics than in our own latitudes, and therefore the error arising from the increasing protection afforded by the growing forest is greatly lessened, von Hann (1908), the acknowledged authority in climatological matters, is ready to accept the general result of these Indian observations as evidence in favor of an influence of forests in increasing the amount of precipitation at least in the tropics. Dr. G. T. Walker, however, the present director of the Meteorological Service of India, in a recent study of supposed changes of climate in India (1910), does not find evidence of an effect of forests in increasing rainfall.

The Java Case

Finally, we may cite the Java case, which is without question the most striking of all. This case was studied and first discussed a good many years ago by Professor Alexander Woeikof, of St. Petersburg. The facts as given by him are these: There are extensive dense forests in the south of Java, while the north coast has been largely deforested. A station, Tjilatjap, on the south coast, distant from the mountains, has a mean annual rainfall almost twice as large as that of three stations (Batavia, Tegal, Samarang) on the north coast. The difference is, in round numbers, about 150 inches against 75 inches. The north side is the windward side for the northwest monsoon, and during the

rainy season (December to March) should have more rain than the south, or lee, side. Yet the fact is that there is about the same rainfall on both coasts at that time. During the southeast monsoon the south (windward) side has a much heavier rainfall than the north (leeward), which is normal. On Celebes, where, according to Woeikof, no such deforestation has taken place, the windward and leeward sides have their normal values of rainfall, the former having a notably larger amount. The case is obviously a very striking one. In reply to a letter from the writer, asking whether newer data from Java tended to strengthen or weaken his previous opinion regarding this case, Dr. Woeikof said:

> I have not modified my views on forests and rainfall. . . . It seems to me that in later years at Tjilatjap, on the south coast of Java, which I cited as a station surrounded by forests, the rainfall is smaller than before. This would confirm my views, as in this formerly very little settled part of the island, forests are rapidly disappearing.

The Java case remains, then, on the authority of one of the best-known meteorologists, a striking example of forest influence on rainfall. So striking, indeed, is it that one is tempted to ask what other possible controlling factors are here active in producing this surprising result.

Recent European Studies

The careful observations which have lately been made in Europe by several investigators (Schubert, Hamberg, Schreiber and others) in western Prussia, Posen, Sweden, Saxony, France and elsewhere, have clearly shown that rain-gauges at forest stations, and above the forest crowns, do generally catch somewhat more rainfall than do the gauges at the parallel stations in open country at the same elevations. The excess varies roughly, we may say, between 1 per cent. and at the most 10 per cent. of the annual mean. But leading European authorities are pretty well agreed that when definite allowance is made for the effects resulting from differences of exposure, due to the better protection of the forest gauges, the apparent excess within the forest is reduced, by the probability of error, to a very narrow margin indeed. In some cases the margin disappears entirely. Schubert, for example, found a summer excess in forested areas of about 6 per cent. Of these 6 per cent., 3 per cent. he believes to be attributable to the better protection of the forest gauge, leaving 3 per cent. And 2 per cent. of these remaining 3 per cent. he thinks still liable to an error. This leaves but 1 per cent.

Conclusion Regarding Rainfall

It appears, therefore, that we have as yet no satisfactory or conclusive evidence that forests, at least in our own latitudes, have a significant effect upon the amount of rain *fall,* as distinguished from the amount of the rain *catch* in the gauge. Nor is there direct and unas-

sailable evidence that our forests increase the frequency of precipitation, although some excellent authorities incline to the view that they do. No one can fairly be called unreasonable if he believes that, after making all proper corrections, there remains no appreciable difference in rainfall inside and outside of our temperate zone forests. Perhaps even the slight remaining differences ought themselves to be "corrected" away. On the other hand, no one can be called unduly optimistic who, knowing the many uncertainties involved in any critical study of rainfall records, gives the forest "the benefit of the doubt" and holds that it really does rain a little more over forests than in the open. But the "little" is, at best, very little, as the latest European observations have shown. We can not, if we will, make it an excess of more than a few hundredths of the total annual rainfall. The margin of difference between the two points of view is thus seen to be very slight indeed. One thing is clear. Granting that *all* of the observed differences between the catch within forests and outside of forests is due to an actual difference in rain *fall*, and not largely to the difference in exposure, the excess over the forest still remains but a small proportion of the annual rainfall. In other words, even the uncorrected observations give a maximum value for forest effects which is itself relatively slight. If, at best, forests can only produce such slight differences over and among the trees themselves, we can not suppose that they will have enough effect upon passing air currents to influence the climate of more distant regions. Hellmann has shown that an increase in the rainfall over a forest, resulting from the slackening of the lower air currents and a readier descent of the raindrops, is accompanied by a lessened fall to leeward. Thus there is equalization; simply a slight difference in distribution.

It is not altogether surprising that one writer has expressed the opinion that "no definite and unassailable result can ever be obtained" by means of such forest meteorological observations as those now made in Europe, and that "there would be little to be gained by a further study of the question." Yet this attitude will hardly commend itself to those who are anxious to have the present uncertainty cleared up, so far as possible. In view of what has already been said, it hardly needs to be stated that, in spite of the deforestation, by lumbering and fire, of large sections in the eastern United States, there is no reliable evidence of any decrease in rainfall, nor of any other change of climate. (It is, however, only fair to say that a good deal of this denuded area has been covered by second-growth timber.) Nor, in spite of the prevailing popular impression to the contrary, is there any reliable evidence whatever that cultivation and tree-planting over extended areas of the west and southwest have resulted in any increase in the amount of precipitation. There is, of course, a better conservation of moisture for plant use. We are surely within the bounds of reason when

we say that there is no hope that we can increase our rainfall really appreciably or effectively by any amount of tree-planting. A whole ocean of water can not give rainfall if the general pressures and temperatures and winds are hostile to precipitation.

As was pointed out at the beginning of this paper, forests are of many different kinds. We can not, therefore, reasonably expect all forests to have the same effects. There may be a difference between tropical and temperate forests, as has already been suggested in the case of Java rainfall, for tropical weather types and rainfall conditions are different from our own, just as tropical forests are different from our own. Tropical rainfalls, as over the great forested Amazon valley, are largely thunderstorm rains, and as forests tend to check air movement, and calms are favorable conditions for convectional overturning, it appears as if tropical forests might be expected to influence rainfall more than our own. Furthermore, from the hot and damp tropical forest, and from the leaves of the closely-crowded tropical trees, there must come a large amount of moisture which will increase the vapor content of the ascending air and tend to increase condensation and rainfall. Thus Woeikof, whose emphasis on the case of Java has been referred to, believes that in low latitudes the vast tropical forests do increase the amount of rainfall. Von Hann, the leading authority on climate, holds that we may conclude "with considerable certainty that, at least in the tropics, the forest may increase the amount of rainfall." Hettner, also, in his work in the tropical Cordillera, came to the conclusion that the forests in the Cordillera of Bogotá favor the growth of clouds and the production of rain. While this is an interesting phase of our discussion, we have as yet no thorough study of tropical conditions by means of the parallel station method. There is also another point. In low latitudes, where the dense tropical forests are found, the rainfall is already so heavy that it is of little or no significance whether there is a good deal more, or a good deal less. In exactly those regions, therefore, where, if anywhere, forests may have a really appreciable influence on rainfall, little or no economic importance attaches to the question. Woeikof believes that rain often begins earlier over tropical forests, and in Mauritius, Walter has called attention to the fact that the number of rainy days seems to be greater over forested areas.

It need hardly be pointed out that, if rain is already falling, the opportunity for it to reach the earth's surface must be better if it falls through the somewhat cooler and damper air over a forest or a grass-covered surface than through a hotter and drier stratum of air over a desert. In the latter case the loss by evaporation may be so great that the drops do not reach the surface at all. Obviously, the contrasts between these two conditions are greatest in the case of the tropical forests and tropical deserts. It must, however, be observed that this

effect is one of the conservation of rain already produced without the action of the forest, not a case of an increase of rainfall directly due to the forest.

Another effect of conservation may sometimes be seen when, after a rain, the low clouds ("fog") continue to hang over a forest, and may give another light shower there while no more rain falls over the fields. In this case, the drops left hanging on the leaves evaporate; the air over the forest may become very damp; a slight cooling will suffice to produce a second falling of the same water which fell previously. This is clearly not a case of an increase of rainfall. It is pretty safe to say that it would rain somewhat oftener, and a little more heavily, over tropical deserts if the surface were covered with vegetation instead of being sandy and therefore heated to a high degree, although the cause of the rain is far beyond the action of desert or forest. But tropical deserts are sandy deserts because the general condition of the atmospheric circulation makes them so, not because they have been deforested.

Influence of Forests in Collecting Moisture from Clouds and Fogs

There is one effect of trees, often observable during dense fogs, which results in the collection and precipitation of water drops which would otherwise not fall to the surface. This is a mechanical collection by trees, or it may be by telegraph and telephone wires, or by the rigging on board ship, of the fog or cloud particles carried against the object in question by the moving air. When the amount of water thus collected is sufficient, drops fall from the collector as a gentle shower. Thus there is an actual increase in the amount of precipitation, although no increase in the amount of condensation. Many years ago, Sir John Herschel, during his residence at the Cape of Good Hope, called attention to the fact that, when low clouds were closely overhead, a shower of rain might be experienced under the trees on the side of Table Mountain, whereas no rain fell outside. The explanation which he gave was inaccurate, but the fact was important. Recently, Marloth has shown that the collection of water droplets from the clouds on Table Mountain is an important factor in supplying moisture for the swamps and springs. A rain-gauge with a bunch of grass fastened on wires around its rim, so that the collected water drops would run into the gauge, gave from ten to thirty-five times as much "rainfall" as an ordinary gauge. Further, the number of horse-power furnished by a stream coming down the mountain decreased more than one half after a fire had burned off the vegetation on the top of the mountain. Abbe has called attention to the "steady dripping of trees enveloped in cloud-fog" on the windward side of Green Mountain, on the Island of Ascension. This mountain owes its name to the fact that it is always green with verdure. From its summit comes the principal

water supply for the garrison, this water being contributed partly by "slight showers" and partly by the "steady dripping" just referred to. "Every exposed object," says Professor Abbe, "contributes its drip." Another case, described by William L. Hall, in the Hawaiian Islands, is that of the collection of the drip from the trees in a region of heavy fog (? cloud) in troughs for the use of cattle. In this locality deforestation would, it is stated, "reduce the productiveness of the plantations, if not ruin them entirely."

The present writer has several times, during fogs, noted the dripping of water from the wires above the sidewalks in his own city. The sidewalks being dry at the time, the drops from each wire made a wet line on the pavements. Again, when steaming through the thick fogs on the Grand Banks of Newfoundland, many of us have seen real, though gentle, showers of rain falling from the wet rigging on to the dry decks.

In winter, when the moisture freezes on the trees, the branches and twigs may become heavily covered with "frost." Fischbach has noted the fact that in winters of deficient snowfall in the Black Forest, he has several times observed that the frost shaken off of the trees by the wind has made possible the use of sledges for transporting wood. In one single European case, reported by Wilhelm, the amount of "rainfall" resulting from the occurrence of such a frost deposit on trees was not far below .05 inch.

In this mechanical collection of water particles by a forest, we seem to have a really effective means of increasing the total *fall* of rain. It is easy to see that if such favorable conditions are often repeated, and where the trees are tall and have many branches, the surface of the ground beneath the forest may easily receive a not inconsiderable supply of moisture. Such action on the part of forests is further aided by the fact that fogs often seem to last longer among trees. Nevertheless, we should remember (1) that the conditions favorable to this particular forest influence are found only locally, especially on forested mountain slopes and tops; (2) that the increase in the fall of rain is limited to the area covered by the forest itself, and is, therefore, not upon soil used for agriculture; and (3) that in the European observations, above referred to, this particular action of forests was at work, as well as all other forest influences, yet the results were, as has been seen, uncertain.

Influence of Forests upon Hail and Other Storms

There has been a widespread impression in parts of Europe that hailstorms avoid forests, and that forests serve to break up and to weaken other storms. The evidence on the question of hailstorms is conflicting, but we may say that the popular impression can be explained on the ground that hail naturally does more damage to tender crops

than to forest trees, and that the damage in the former case would attract, in the latter would largely escape notice. Further, as regards storms and high winds in general, forests do, as has been seen, tend to check wind velocity, and thus to reduce the local violence of a gale. On the other hand, however, recent investigations in Germany have shown that in thunderstorms the obliquely descending component of the wind can be but slightly, if at all, affected by forests, whose trees are easily uprooted by these winds.

The Hygienic Influence of Forests

There are several ways in which forests have a hygienic significance, and the location of many of our well-known health resorts in or near extended forest areas is, therefore, well planned and logical. The reduced wind movement; the protection against the severest extremes of summer heat and of winter cold; the marked decrease of dust and of other atmospheric impurities; the grateful shade and lack of glare on sunny days; the relatively small number of microorganisms—all these are helpful, not only to those who are ill or convalescent, but to persons in good health; all these are arguments in favor of wooded parks in and in close proximity to our cities. In addition, but of non-climatic importance, there are the scenic attractions of the forests; the relief from the noise and the bustle of the city; the fragrance of the air among the evergreen trees, and the frequent intermingling of river and lake and mountain, all of which features contribute to the popularity of forest sanitaria and pleasure resorts. So far as the composition of forest air is concerned, there is no further notable difference between it and the air outside. We can not, therefore, look for any marked curative effects on that account. The much-discussed beneficial effects of the ozone in the forest air seem to lack the support of observation.

The Influence of Forests upon Water-supply, Erosion and Floods

The preceding discussion has dealt with the influence of forests upon climate. Therefore no mention has been made of their relation to the conservation of the water-supply, to erosion and to floods, all of which are non-climatic, or at any rate only indirectly climatic effects. There is still a great deal to be learned about the use of forests in connection with water-supplies; their effects in holding back rainfall and in storing the winter snow; their relation to floods, and ground-water, and springs and erosion. The "last word" in this discussion is to be found in the "Final Report of the National Highways Commission" (Sen. Doc. No. 469, 62d Cong., 2 sess., 1912). From this report we take the following statements, which are of peculiar interest, because they represent the conclusions and recommendations which have been reached

after a thorough study of the different phases of this many-sided problem. It is easy to see why different observers, under different conditions, have reached such divergent results.

Whatever influence forests may exert upon precipitation, run-off and erosion, it is evidently greatest in the mountainous regions where the rainfall is heaviest, slopes steepest and run-off most rapid. Here also the land is less useful for other purposes. The extent of the influence of forests upon these three factors varies greatly, according to circumstances involved in each case. Under one set of conditions, forests may benefit stream flow and mitigate floods, while under other conditions they may have the opposite effect. In no case can they be relied upon to prevent either floods or low-water conditions. There is substantial agreement on this point. Nor is their influence extensive enough to warrant their use as the only means of securing the uniformity of stream flow which is desirable for navigation or the development of water power. For this purpose storage reservoirs would be much more effective. The prevention of erosion undoubtedly outweighs all other benefits of forestation and constitutes one of the most necessary phases of conservation. The commission favors the prevention of deforestation of mountain slopes wherever the land is unsuitable for agricultural purposes, and urges the reforestation of those tracts which have already been denuded, not only when located at the headwaters of navigable streams, but wherever this would be the most valuable use of the land. The increasing pressure of population upon subsistence will make it necessary to use for agricultural purposes all land suitable for cultivation. The influence of forests upon stream flow and erosion is not sufficient to warrant their retention except where the land is unsuited for other purposes. Furthermore, it is possible, if correct methods of agriculture are employed, to retain for cultivation areas located on steep hillsides. This has been successfully accomplished in other countries by terracing and by other means. It must be remembered, however, that reforestation alone can accomplish little toward preventing erosion. The prevention of forest fires, the regulation of hillside farming and the prohibition of complete denudation of mountain tracts, where the soil cover is thin and the land unsuited for agricultural purposes, are also necessary. Forests retard the melting of snow in the spring, and, by allowing the water from this source to be absorbed, exercise a beneficial influence upon stream flow, but should heavy spring rains fall upon the snow thus preserved and cause it to melt within a few hours, the effect of the forest is in such a case to aggravate rather than ameliorate flood conditions. It thus appears that under one set of conditions forests may exercise a beneficial influence upon stream flow and floods, while under another their influence will be harmful.

But these problems do not directly concern the climatologist. He is satisfied if he can make clear, as he sees it, the influence of the forest as a control of climate. If his statements are often disappointingly broad and generalized, it is because he has not the needed scientific basis for making them otherwise.

GOETHE AND THE CHEMISTS

By ROY TEMPLE HOUSE

NORMAN, OKLA.

WE learn from "Dichtung und Wahrheit" that when the young Goethe came home ill from the University of Leipzig in 1768, he fell under the influence of a physician who claimed to have found an infallible panacea which he did not dare use because he was afraid of legal action against him. His young patient was suddenly seized with an attack of violent illness which threatened his life, and the physician was persuaded to use his mysterious drug, with the result that the young man at once began to mend and soon recovered. This experience was the beginning of Goethe's infatuation for alchemy, which began fantastically enough—although we have no occasion to quarrel with it when we remember its influence on "Faust" and "Die Wahlverwandschaften"—but became in the course of time a serious and profitable interest in chemical investigation. Although he was never a thoroughly grounded chemist himself, his marvelous skill in forming mutually profitable partnerships with specialists made his chemical activity of real and great significance.

Established at Weimar as an official member of the government, he early made friends with the interesting court apothecary, Wilhelm Heinrich Sebastian Buchholz. This gentleman had studied medicine and received his medical degree, but after leaving school had devoted himself to pharmacy and had bought what was then the only apothecary-shop in Weimar. He was a prosperous and jovial man of the world and played an important part in the social life of the little capital, but he was none the less a genuine scientist, and Goethe's debt to him was a considerable one, as he himself admits in the narrative entitled "Geschichte meines botanischen Studiums" which closes the "Metamorphose der Pflanzen." Buchholz kept up a large garden which contained, we are told, "not only the herbs which he needed for his business, but rare and newly discovered plants." He seems to have kept himself well informed as to new discoveries and developments in his own and related sciences, and when the Montgolfier brothers sent up their balloon from Avignon in 1783, Buchholz tried a similar experiment at Weimar; but Goethe wrote his friend Knebel, describing the first attempt: "He torments the air in vain; the balls refuse to rise." His later efforts seem to have been crowned with success, to the astonishment of the multitude and the distress of the pigeons; and Goethe,

delighted with this and later flights which he witnessed in Cassel, seems to have finally reached the point of performing the feat himself. He worked also with Buchholz at the analysis of water and its purification by the use of powdered charcoal; and the pharmacist remained until his death, which occurred in 1798, an active and honored member of Goethe's celebrated "Freitaggesellschaft."

A brother of Goethe's friend Friedrich Hildebrand von Einsiedel had studied mining and metallurgy, secured the title of *Bergrat* (counsellor of mines) and established a laboratory in Weimar. Goethe appears to have visited him frequently, but we learn of nothing in the way of genuine additions to the world's knowledge that developed from his labors. Current references to him indicate that he occupied himself largely with marvelous chemical exhibitions for lady visitors; and Wilhelm Bode describes him as a man of natural gifts, who, "although he knew more about chemistry, geology, even of the history of countries and races, than all the masters, doctors, scribes and priests," nevertheless accomplished nothing of serious importance. In 1785 he was sent to North Africa by the French government to study mining conditions there, and Goethe mentions the enterprise several times in his letters; not, however, so much for its scientific importance as because of the fact that he took with him one of the most prominent lady members of Weimar Court society, after she had succeeded in spreading the report of her death and had had a dummy buried in her place. On his return, he gave up his scientific investigations, and Goethe purchased his apparatus for his fosterling, the University of Jena; so that in spite of his lack of energy, August von Einseidel played a very essential part in the scientific activity of the Duchy of Weimar, after all.

One of the assistants of the talented apothecary Buchholz was a young Saxon, Friedrich August Göttling, who was destined to surpass his master. The son of a poor minister, beginning life as an apothecary's assistant, he published in 1778 an "Introduction to Pharmaceutical Chemistry," and so interested Goethe that the latter made it possible for him to study at Göttingen from 1784 till 1787, and to travel and observe industrial conditions in Holland and England. Shortly after his return his powerful patron secured his appointment to a professorship at Jena, where he was very profitably active for many years. Göttling will be remembered longest for his part in the phlogiston discussion. It was about 1700 that Stahl promulgated his theory that combustion involved a loss of substance. Although Lavoisier (1743–1794) proved conclusively that burning is oxidation, *i. e.*, an addition instead of a subtraction, German chemists of Göttling's time, partly perhaps for patriotic reasons, still clung to the exploded theory, and Göttling, who published between 1794 and 1798 a "Contribution toward the Justification of Antiphlogistic Chemistry," stood almost alone among

his countrymen in his views on this question. It is true that he was not entirely free from the influence of the old method of reasoning, as is shown by the fact that he tried to explain the burning of phosphorus in nitrogen—which of course occurred only because he did not in that day have instruments which made it possible to exhaust all the oxygen —by the assumption of a new and mysterious substance which was in itself the essence of light and heat.

He and Goethe worked together at the extraction of sugar from beets and at other enterprises, and Goethe was his regular and faithful student as well as his colleague and his patron. The great poet became an enthusiastic champion of the new chemistry, and published in Schiller's "Musenalmanach" in 1797, an epigram which ran:

> Schon ein Irrlicht sah ich verschwinden, dich Phlogiston! Balde,
> O Newtonisch Gespenst, folgst du dem Brüderchen nach.
> (Will o' the Wisp, Phlogiston, I see thou hast vanished. And shortly
> Newton's vague specter shall flee; flee as his brother has fled.)

But even Goethe's eloquent fulminations were not powerful enough to banish the Newtonian specter.

After Göttling's death Goethe continued to interest himself in the chemist's widow and little son. The latter, Karl Wilhelm Göttling, became librarian and professor of philology at Jena, and was later to repay in some measure his old patron's kindness to himself and his father, by assisting in preparing the complete edition of his works.

Dr. Alexander Nikolaus von Scherer, born in Russia in 1771, was recommended to Goethe in 1797 by Wilhelm von Humboldt. The poet furnished the newcomer a laboratory and equipment, and both he and Duke Karl August took the warmest interest in him. He made some interesting discoveries with phosphorus, and from 1798 he edited in Jena the *Allgemeine Journal der Chemie.* He died in Russia in 1824, a member of the St. Petersburg Academy.

One of Scherer's assistants in the conduct of the *Journal* was the somewhat younger Johann Wilhelm Ritter, a Silesian, who came to Jena penniless in 1795. He entered the university, and at once attracted general attention by his scientific aptitude. Ritter made some discoveries of great value. He discovered the chemically active dark rays in the solar spectrum, and accomplished some interesting results with galvanism. He obtained hydrogen and oxygen by disorganizing water with the electric current, he decomposed sulphate of copper, and he constructed a "charging pile" which was a precursor of the modern accumulator. Goethe studied and worked with him a great deal, especially during the years 1800 and 1801. He was inclined to be somewhat speculative and mystical, and especially after his call to the University of Munich in 1804, he gave himself up to various lines of fantastic theorizing. He became deeply interested in animal magnetism,

experimented with divining rods for the location of minerals and water below the surface, and developed a theory of siderism that for a time enjoyed considerable notoriety. His writings continued to exert an influence over Goethe, and their effect is traceable in the latter's novel "Die Wahlverwandschaften."

But the most notable of all Goethe's chemical helpers was the young Bavarian, Johann Wolfgang Döbereiner. The son of poor parents, this young man secured education enough to become a pharmacist's assistant, and even came so far at one time as to own a small establishment of his own. But the fates seemed working against him. Although he had published a number of monographs which had made him nationally known, it seemed for a time as if he would be unable to gain even the most meager living for himself and his family. In 1810 he was penniless and unable to secure the humblest position as an apothecary's assistant, when Duke Karl August and Goethe, whose attention had been attracted to him by his publications and who were confident that he would be competent and useful in spite of his irregular education, called him to Jena to replace the deceased Göttling.

This was the beginning of a long and useful period of forty years at Jena, ending only with his death, although in the course of his activity there he received at least five more favorable offers from other institutions. His was a faithful, affectionate nature, and he felt such gratitude to his Weimar patrons for having come to his assistance at the time of his greatest need that he refused to leave on any terms. He showed his idealistic turn of mind very strikingly at other points. Although he is responsible for several inventions which have great industrial value, he always refused—and in this matter Goethe was heartily at one with him—to impose any restrictions on their use, but threw them open to the world and allowed others to reap the profits. He was always ready to give free advice to industrials, and made large fortunes for others, while he himself was struggling along on the utterly inadequate salary which was all his little university was able to spare him.

Döbereiner did useful work in stoichiometry and atomic measurements; as Gay-Lussac had established the laws of proportion in inorganic chemical compounds of gases, so the young German was able to develop the proportions for organic compounds. His discussions "On Pneumatic Chemistry" were valuable additions to the chemistry of gases in general. His measurements of the amount of carbonic acid gas which escapes in the alcoholic fermentation of sugar and the publications which he based on the data thus obtained, extended knowledge of a process which Lavoisier had already established in a general and partially only theoretical fashion. In 1829 appeared his "Attempt at a Grouping of the Elements according to their Analogy." Here occurred for the first time the celebrated arrangement into triads—chlorine, bromine, iodine,

etc. It was too early for his assertions with regard to atomic weights to be verified, but it is surprising how nearly accurate his system was.

Döbereiner, between the years 1820 and 1830, made some remarkable discoveries with platinum. He heated the double chloride of platinum and ammonium to a glow and obtained what he called platinum sponge. He found that this light, porous substance, when slightly warmed and placed in contact with alcohol, becomes red hot, and that if it is set in a mixture of hydrogen and oxygen, it grows hot without the application of heat from without. He drove hydrogen against a piece of the platinum sponge surrounded by atmospheric air, and found that the platinum was heated and the hydrogen ignited by the process. He found also that metallic platinum, in contact with hydrogen gas, causes it to unite with oxygen to form water. These experiments excited attention and admiration throughout the chemical world. The great Swede Berzelius termed his discoveries "the most brilliant of the generation," and the most celebrated of Döbereiner's pupils, Runge, the discoverer of aniline, ranked his master as "the most famous of living chemists."

We have said that a great deal of Döbereiner's work has industrial importance. He saw how to derive acetic acid from alcohol, and he was able to hasten the process of vinegar formation by the help of powdered platinum. He applied his discovery of the ignition of hydrogen by contact with platinum sponge, to the construction of an instrument called the "Döbereiner igniter," which enjoyed great popularity until it was superseded by friction matches. But this quality of platinum is still utilized in gas tips and in the manufacture of sulphuric acid.

Döbereiner experimented with the possibilities of coal-gas for illuminating purposes, obtaining his gas by the action of steam on coal at a very high temperature; and he was the first to discover the usefulness of the mixture of hydrogen and carbonic oxide called "water-gas." There has been some discussion on this point, but a letter of Goethe's dated December 5, 1819, proves that Döbereiner had studied the mixture seven years before a process for the production of water-gas was patented in England.

The poet and the chemist were faithful correspondents, and we have sixty-five letters of Goethe to Döbereiner and five of those written by the chemist in return, which prove that they were on very intimate terms. The two would spend entire days together in the laboratory at Jena, and other days together in Weimar, where Goethe maintained a laboratory especially equipped for his friend's use. We have a poem of Goethe's dedicated to the scientist on the occasion of the latter's birthday, and we find again and again that the chemist's patron tried to

secure an increase in salary and better equipment for his faithful friend and helper. It was due to Goethe's influence that Döbereiner was nearly or quite the first chemistry professor in Germany who was able to give practical as well as theoretical class instruction in his subject.

Döbereiner made mistakes which are traceable to Goethe's influence. The two were certain, for example, that electricity is the source of life, and this belief led to some strange and quaint theories which smack a little of the old days of alchemy. Both were inclined to undervalue equipment, and to look upon the fields and the hills as an adequate laboratory. But on the whole, Goethe gave as much and as usefully as he took. Alexander von Humboldt had said that the immortal poet-philosopher's views of natural phenomena had "elevated him, equipped him as it were with new organs." And Döbereiner showed his gratitude not only in words, but in every tangible way that came within his reach. He was always ready to give time and thought to assisting his master wherever his talents made him useful, from the preparation of a tooth powder to the deciphering of a Latin epigram of the old poet Antonius dealing with a poison and an antidote—an epigram which was absolutely dark to the scholars, but became light as day with the help of the chemist.

Döbereiner was the youngest of the famous Weimar group, and many years after the death of the great chief and center of that group, the old Jena scientist found his greatest pleasure in telling the younger generation of the golden age of German intellectual activity.

THE DOMESTICATION OF AMERICAN GRAPES

By Professor U. P. HEDRICK

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THERE are about forty species of grapes in the world, more than half of which are found in North America. Few other plants on this continent grow wild under such varied conditions and over such extended areas. Thus, wild grapes are found in the warmer parts of New Brunswick; on the shores of the Great Lakes; everywhere in the rich woodlands and thickets of the North and Middle Atlantic States; on the limestone soils in the mountainous parts of Kentucky, Tennessee and the Virginias; and they thrive in the sandy woods, sea plains and reef-keys of the South Atlantic and Gulf States, where a single vine of the Scuppernong often clambers over trees and shrubs for a hundred feet or more. While not so common west of the Mississippi, yet some kind of wild grape is found from North Dakota to Texas; grapes grow on the mountains and in the canyons of all the Rocky Mountain States; and several species thrive on the Mexican borders and in the far southwest, where they furnished the early Spanish *padres* with grapes for wine and suggested the planting of the first vineyards in America.

While it is possible that all of the native grapes have descended from an original species, the types are now as diverse as the regions they inhabit. The wild grapes of the forests have long slender trunks and branches whereby their leaves are better exposed to the sunlight. Two shrubby species do not attain a greater height than four or five feet; these grow in sandy soils, or among the rocks well exposed to sun and air. Another runs on the ground and bears foliage almost evergreen. The stem of one species attains a diameter of nearly a foot, bearing its foliage in a great canopy; from this giant form the species vary to sorts with slender, graceful, almost delicate, climbing vines. Wild grapes are quite as varied in climatic adaptations as in structure of vine, and grow luxuriantly and bear fruit in almost every condition of heat or cold, wet or dry, capable of supporting fruit-culture in America. So many of the kinds have horticultural possibilities that it seems certain that some of them can be domesticated in all of the agricultural regions of the country, their natural plasticity indicating, even if it were not known from experience, that all can be domesticated.

Leif the Lucky, the first European to visit America, if the Icelandic records be true, christened the new land Wineland after its grapes. Captain John Hawkins, who visited the Spanish settlements in Florida in 1565, mentions the wild grapes among the resources of the New World, with the statement that the Spaniards "had made twenty hogs-

heads of wine in a single season." Amadas and Barlowe, sent out by Raleigh in 1584, described the coasts of the Carolinas as, "so full of grapes that in all the world like abundance can not be found." Captain John Smith, writing in 1606, describes the grapes of Virginia and recommends the culture of the vine as an industry for the newly founded colony. Few, indeed, are the explorers of the Atlantic seaboard who do not mention grapes among the plants of the country. Yet none saw intrinsic value in these wild vines. To the Europeans the grapes of the Old World alone were worth cultivating and the vines growing everywhere in America only suggested that the grape they had known across the sea might be grown in the new home.

During colonial times and the first half century of the union, efforts to grow European varieties of grapes in America were continuous. Some of the experiments were on a large scale and in the hands of expert vine growers, yet all resulted in failure. Several large companies undertook grape-growing and wine-making in the years following the Revolution; the efforts of a few of these are worth noting.

Peter Legaux, a Frenchman, founded a company to grow grapes at Spring Mill, near Philadelphia, in 1793. John James Dufour, a Swiss, came to America in 1793 to engage in grape-growing and became the head of the Kentucky Vineyard Society in the valley of the Ohio in Kentucky and Indiana. The Harmonists, a religious-socialistic community, planted ten acres of grapes about 1805 near Pittsburgh, and later made another plantation at New Harmony, Indiana. When the Napoleonic wars were over, a number of Bonaparte's exiled officers came to America and founded the Vine and Olive Colony on land granted them by Congress on the Tombigbee River in Alabama. Here one hundred and fifty French settlers spent several years in vain attempts to grow European grapes in America. In a rough and hardly explored country, part of which was overflowed half the year, with all the sickness inherent to such a location, unaccustomed to field work and the hardships of a new country, the attempt to grow grapes, where failure was predestined because of natural obstacles, became for these French officers and their families a tragedy which ended in great suffering and the impoverishment of all and the death of many.

It is only on the Pacific coast and in favored valleys of the Rocky Mountains that *Vitis vinifera,* the grape of the Old World, can be grown. The great viticultural industry of California is founded upon the successful culture of this species. The native grapes can be grown, but they can not compete on the Pacific coast with the Old World grape for any purpose. The success attained in the cultivation of this species west of the continental divide makes all the more remarkable its complete failure east of the divide.

For three centuries from the first recorded attempt to grow the Old World grapes in America, the causes of the failures were a mystery.

As one of the first experimenters stated, "a sickness takes hold of the vines and they die." The agent causing the sickness is the phylloxera, a tiny plant louse, undiscovered until the last half of the nineteenth century, which works on the leaves and roots of the European grapes, but which does comparatively little harm to American species. Undoubtedly, the resistance of native grapes to the phylloxera is due to natural selection in the contest that has been going on for untold ages between host and parasite. Three other pests, black-rot, downy mildew and powdery mildew, are destructive to European grapes in America. The climate, too, in eastern North America alternates between hot and cold, wet and dry, and the Old World grapes grow well only in equable temperatures and conditions of humidity. The leaves of the Old World grape are thin and soft and the roots fleshy; the leaves of the American species are thick and leathery and the roots hard and fibrous. These differences in the structure of the species of *Vitis* explain their adaptations to the two climates.

That American viticulture must depend upon the native species for its varieties began to be recognized at the beginning of the nineteenth century, when several large companies engaged in growing foreign grapes failed, and a meritorious native grape made its appearance. The vine of promise was a variety known as the Alexander. Thomas Jefferson, ever alert for the agricultural welfare of the nation, writing in 1809 to John Adlum, one of the first experimenters with an American species, voiced the sentiment of grape experimenters, in speaking of the Alexander:

> I think it will be well to push the culture of this grape without losing time and efforts in the search of foreign vines, which it will take centuries to adapt to our soil and climate.

The Alexander is an offshoot of the common fox grape, *Vitis labrusca,* found in the woods on the Atlantic coast from Maine to Georgia and occasionally in the Mississippi Valley. The history of the variety dates back to just before the Revolutionary War, when, according to William Bartram, the Quaker botanist, it was found growing in the vicinity of Philadelphia, by John Alexander, gardener to Governor Penn of Pennsylvania. Curiously enough, it came into general cultivation through the deception of a nurseryman. Peter Legaux, mentioned before, in 1801 sold the Kentucky Vineyard Society fifteen hundred grape cuttings, which he said had been taken from an European grape, introduced from the Cape of Good Hope, therefore, called the "Cape" grape. Legaux's grape turned out to be the old Alexander. In the new home the spurious "Cape" grew wonderfully well and as the knowledge of its fruitfulness in Kentucky, Ohio and Indiana spread, demand for it increased and with remarkable rapidity, considering the time, it came into general cultivation in the parts of the United States then settled.

Of the several species of American grapes now under cultivation,

Vitis labrusca, first represented by the Alexander, has furnished more cultivated varieties than all the other American species together, no less than 500 of its varieties having been grown in the vineyards of the country. There are several reasons why it is the most generally cultivated species. It is native to the parts of the United States in which agriculture soonest advanced to a state where fruits were desired. In the wild, the Labrusca grapes are the most attractive, being largest and handsomest in color—among all grapes it alone shows black, white and red-fruited forms on wild vines. There is a northern and a southern form of the species and its varieties are therefore widely adapted to climates and to soils. The flavor of the fruits of this species, all things considered, is rather better than that of any other of our wild grapes, though the skins in most of its varieties have a peculiar aroma, somewhat pronounced in the well-known Concord, Niagara and Worden, which is disagreeble to any who are accustomed to the pure flavors of the European grapes. Unfortunately few varieties of this species are adapted to wine-making, as the fruits lack both sugar and acid and impart to wines an unpleasant aroma and taste. All varieties of *Vitis labrusca* submit well to vineyard operations and are vigorous, hardy and productive, though they are more subject to the dreaded phylloxera than are most of the other cultivated native species.

Of the many grapes of the *labrusca* type, at least two deserve brief mention.

The Catawba, the first American grape of commercial importance, is the most interesting variety of its species. The origin of the variety is not certainly known, but all evidence points to its having been found about 1800 on the banks of the Catawba River, North Carolina. It was introduced into general cultivation by Major John Adlum, soldier of the revolution, judge, surveyor, and author of the first American book on grapes. Adlum maintained an experimental vineyard in the District of Columbia, whence in 1823 he began the distribution of the Catawba. At that time the center of American grape culture was about Cincinnati, and an early shipment of Adlum's Catawbas went to Nicholas Longworth, grandfather of the present bearer of that name, and was by him distributed throughout the grape-growing centers of the country. As one of the first to test new varieties of American grapes, to grow them largely and to make wine commercially from them, Nicholas Longworth is known as the "father of American grape culture."

The Catawba is still one of the four leading varieties in the vineyards of eastern America. The characters whereby its high place is maintained among grapes are: great elasticity of constitution, by reason of which it is adapted to many environments; rich flavor, long-keeping quality, and handsome appearance, qualities which make it a very good dessert grape; high sugar content and a rich flavor of juice, so that

from this grape is made a very good sweet or dry wine, the latter entering into a blend for nearly all of the champagne produced in eastern America. The vines, too, are vigorous, hardy and productive. The characters of Catawba are readily transmissible and it has many purebred or hybrid offspring which more or less resemble it.

The second commercial grape of importance in American viticulture is the Concord, which came from the seed of a wild grape planted in the fall of 1843 by Ephraim W. Bull, of Concord, Massachusetts. The new variety was disseminated in the spring of 1854, and from the time of its introduction the spread of the culture of this grape was phenomenal. By 1860 it was the leading grape in America and so remains. It furnishes, with the varieties that have sprung from it, seventy-five per cent. of the grapes grown in eastern America. The characters which distinguish it are: adaptability to various soils, fruitfulness, hardiness, resistance to diseases and insects, certainty of maturity and attractive appearance. It is produced so cheaply that no other grape can compete with it in the markets. It is, as Horace Greeley well denominated it in awarding it the Greeley prize for the best American grape, "the grape for the millions."

Long before the northern fox grapes had attained prominence in the vineyards of the north, the Scuppernong had been partially domesticated in the south. It is a variety of *Vitis rotundifolia,* a species which runs riot from the Potomac to the Gulf, thriving in many diverse soils, but growing only in the southern climate and preferring the seacoast. The Scuppernong has been cultivated somewhat for its fruit or as an ornamental from the earliest colonial times. It is certain that wine was made from this species by the English settlers at Jamestown. Vines of it are now to be found on arbors, in gardens, or half wild on fences in nearly every farm in the South Atlantic States. That the *rotundifolia* grapes have not more generally been brought under cultivation is due to the bountifulness of the wild vines, which has obviated the necessity of domesticating them. The fruit of its varieties, to a palate unaccustomed to them, is not very acceptable, having a musky flavor and odor and a sweet, juicy pulp, which is lacking in sprightliness. Many, however, acquire a taste for these grapes and find them pleasant eating. The wines from *Vitis rotundifolia* partake too much of the muskiness of the fruit unless blended with those of other species. The great defect of this grape is that the berries part from the pedicels as they ripen and perfect bunches of grapes can not be had—in fact, the crop is often harvested by shaking the vines so that the berries drop on sheets beneath. Despite these defects a dozen or more varieties of *rotundifolias* are now under general cultivation in the cotton belt and interest in their domestication is increasing.

The south has another grape which, while not so early brought under domestication or now so generally grown, has greater horticultural pos-

sibilities than *Vitis rotundifolia.* This is *Vitis æstivalis,* the summer grape, or, to distinguish it from the *rotundifolias,* the bunch grape of southern forests. The *æstivalis* grapes are preeminent in wine-making in eastern America. The wines from this species make the best red wines, usually of the claret and Burgundy types, to be had from American vines. A defect of these grapes is that they contain an excess of some of the necessary elements which make good wines; as color, tannin, acidity and bouquet, but these faults are easily remedied by blending. There are now a score or more well-known varieties of *Vitis æstivalis,* of which the best known is Norton, which probably originated with Dr. D. N. Norton, of Richmond, Virginia, in the early part of the nineteenth century. The berries of the true *æstivalis* grapes are too small, too destitute of pulp and too tart to make good dessert fruits. Domestication of this species has been greatly retarded by a peculiarity of the species which hinders in its propagation. Grapes are best propagated from cuttings, but this species is not easily reproduced from cuttings and the difficulty of securing good young vines has been a serious handicap in its culture.

There are two sub-species of *Vitis æstivalis* which promise much for American viticulture. *Vitis æstivalis bourquiniana,* known only under cultivation and of very doubtful botanical standing, furnishes American viticulture several valuable varieties. Chief of these is the Delaware, the introduction of which sixty years ago from the town of Delaware, Ohio, raised the standard in quality of our grapes to that of the Old World. No European grape has a richer or more delicate flavor or a more pleasing aroma than the Delaware. While a northern grape it can be grown in the south and thrives under so many different climatic and soil conditions and under all is so fruitful that, next to the Concord, it is the most popular American grape for garden, vineyard and wine-press. Without question, however, the Delaware contains a trace of European blood.

Another offshoot of this sub-species is the Herbemont, which in the south holds the same rank that the Concord has in the north. The variety is grown only south of the Ohio, where it is esteemed by all for a dessert grape and for its light red wine. It is one of the few American varieties which finds favor in France, being cultivated in southwest France as a wine grape. Its history goes back to a colony of French Huguenots in Georgia before the Revolutionary War. Very similar to the Herbemont is the Lenoir, also with a history tracing back to the French in the Carolinas or Georgia in the eighteenth century.

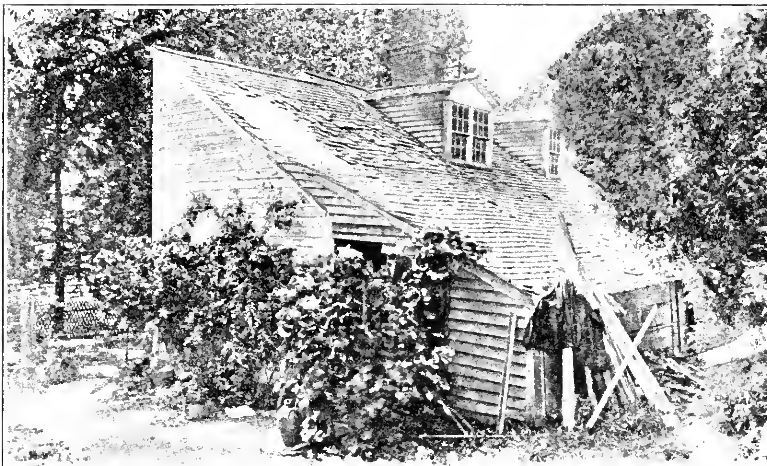
The other sub-species of *Vitis æstivalis* is *Vitis æstivalis lincecumii,* the post-oak grape of Texas and of the southern part of the Mississippi Valley. Recently this wild grape has been brought under domestication and from it have been bred a number of most promising varieties for hot and dry regions.

As agriculture becomes more diversified in the south, when cotton and tobacco no longer hold complete sway, the varieties of *Vitis æstivalis* and its two sub-species will become important agricultural assets.

The north, too, has a wine grape from which wines of their types nearly equalling those of the southern *æstivalis* are made. This is *Vitis riparia,* the river grape, the most widely distributed of any of the native species. It grows as far north as Quebec, south to the Gulf of Mexico, and from the Atlantic to the Rocky Mountains. Fully a century ago a wine-grape of this species was cultivated under the name Worthington, but the attention of vineyardists was not turned to the *riparias* until after the middle of the last century, when the qualities of its vines attracted the attention of French viticulturists. Phylloxera had been introduced from America into France and threatened the existence of French vineyards. After trying all possible remedies for the scourge it was discovered that it could be overcome by grafting the European grapes on American vines resistant to the phylloxers. A trial of the promising species of New World grapes showed that the vines of *Vitis riparia* were best suited for the reconstruction of French vineyards, being not only resistant to the phylloxera, but also vigorous and hardy. It is interesting to note that a large proportion of the vines of Europe, California and other grape-growing regions are grafted on the roots of this or of other American species and the viticulture of the world is thus largely dependent upon these grapes.

The French found that a number of the *riparia* grapes introduced for their roots were valuable as direct producers for wines. The fruits of *Vitis riparia* are too small and too sour for dessert, but they are free from the disagreeable tastes and aromas of some of our native grapes and therefore make very good wines. The best known of the varieties of this species is the Clinton, which is generally thought to have originated in the yard of Dr. Noyes, of Hamilton College, Clinton, New York, about 1820. It is, however, probably the Worthington, of which the origin is unknown, renamed. There are possibly a hundred or more grapes now under cultivation wholly or in part from *Vitis riparia,* most of them hybrids with the American *labrusca* and the European *vinifera,* with both of which it hybridizes freely.

A curious fact in the domestication of all these species is that they did not come under cultivation until forms of them striking in value had been found. Catawba, representing the *labrusca* grapes; the Scuppernong, the *rotundifolias;* Norton from *Vitis æstivalis;* the Delaware and Herbemont from the *Bourquiniana* grapes; and Clinton from *Vitis riparia,* are, after a century scarcely excelled, though in each species there are many new varieties. It is with grapes as with all fruits; the majority of the best varieties originate by chance and for the reason that a prodigious number of natural seedlings, pure or cross-bred, arise, and natural selection, while wasteful, is wonderfully effective.



The Bull House, Home of the Concord Grape

That our best grapes have come from chance is not because of a lack of human effort to produce superior varieties. Of all fruits the grape has received most attention in America from the generation of plant-breeders just passing. Their product is represented by fifteen hundred varieties, a medley of the more or less heterogeneous characters of a dozen species. That these have not excelled is due more to a lack of knowledge of plant-breeding than to a lack of effort. Now that order and system, undreamed of a generation ago, have been disclosed by the brilliant discoveries in plant-breeding of the last decade, future efforts to improve grapes ought to be more fruitful than those of the past.

As early as 1822, Nuttall, a noted botanist, then at Harvard, recommended "hybrids betwixt the European vine and those of the United States which would better answer the variable climates of North America." In 1830 William Robert Prince, fourth proprietor of the then famous Linnean botanic nursery at Flushing, Long Island, grew ten thousand seedling grapes "from an admixture under every variety of circumstance." This was probably the first attempt on a large scale to improve the native grapes by hybridizing, though little seems to have come of it. Later a Dr. Valk, also of Flushing, grew hybrids from which he obtained the Ada, the first named hybrid, the introduction of which started hybridizers to work in all parts of the country where grapes were grown.

Soon after Valk's hybrid was sent out, E. S. Rogers, of Salem, Massachusetts, and J. H. Ricketts, of Newburgh, New York, began to give viticulturists hybrids of the European *vinifera* and the American species which were so promising that enthusiasm and speculation in grape-growing ran riot. Never before nor since has grape-growing received the attention in America given it during the decade succeeding the

Shoot of *Vitis labrusca*, the Northern Fox Grape, the most Widely Cultivated of our Native Grape.

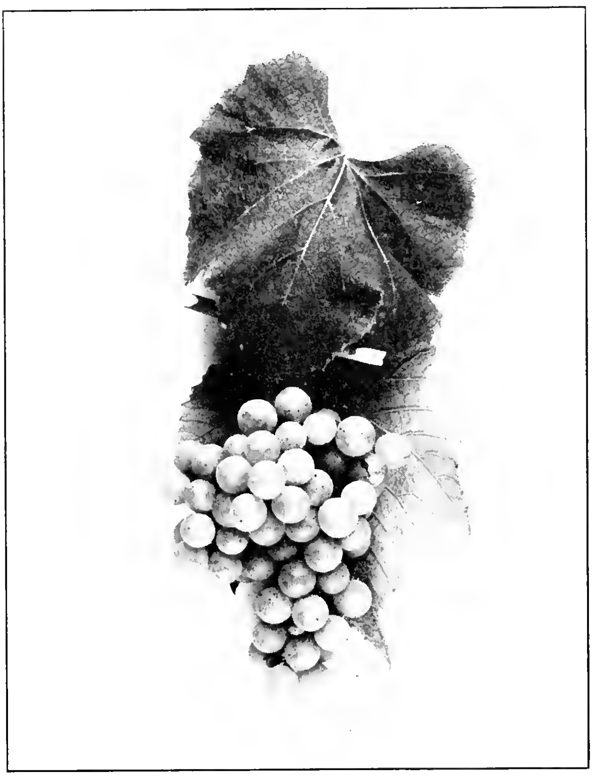
introduction of Rogers' hybrids. It was the golden era for nurserymen. One of the grape propagators of that time tells of carrying, during this boom, a thousand dollars' worth of plants on his back from the nursery to the express office. It was the expectation of all that we were to grow in America, in these hybrids, grapes but little inferior, if at all, to those of Europe.

A statement of the difference between European and American grapes shows why American viticulturists are so eager to grow either purebreds from the foreign grape or hybrids with it.

European grapes have a higher sugar and solid content than the American species; they, therefore, make rather better wines, excepting champagnes, and keep much longer after harvesting and can be made into raisins. So, too, they have a greater variety of flavors, which are more delicate, yet richer, with a pleasanter aroma, seldom so acid, and are always lacking the disagreeable, rancid odor and taste, the "foxiness," of many American varieties. There is, however, an unpleasant astringency in some of the *vinifera* grapes and many varieties are without character of flavor. American table grapes, on the other hand, are more refreshing, the unfermented juice makes a pleasanter drink, all of the grape juice of the markets being made from native grapes, and,

lacking sweetness and richness, they do not cloy the appetite so quickly. The bunches and berries of the *vinifera* grapes are larger, more attractive, and are borne in greater quantities. The pulp, seeds and skins are somewhat objectionable in all of the native species and scarcely so at all in *Vitis vinifera*. The berries of the native grapes shell from the stems so quickly that the bunches do not ship well. The vines of the Old World grapes are more compact in habit and require less pruning and training than do those of the native grapes, and, as a species, probably through long cultivation, they are adapted to more kinds of soil, to greater differences in environment, and are more easily propagated than the American species.

Because of these points of superiority in the Old World grape, since Valk, Allen and Rogers showed the way, American grape-breeders have sought to unite by hybridization the good characters of *Vitis vinifera* with those of the American grapes. Nearly half of the fifteen hundred grapes cultivated in eastern America have more or less *vinifera* blood in them. Yet despite the efforts of breeders few of these hybrids have commercial value. Whether because they are naturally better fixed, or long cultivation has more firmly established them, the vine



LEAF AND FRUIT OF A WHITE CULTIVATED LABRUSCA.

SHOOT OF *Vitis rotundifolia*, THE SCUPPERNONG OR SOUTHERN FOX GRAPE.

characters of *Vitis vinifera* more often appear in varieties arising as primary hybrids between the *vinifera* grapes and the native species, and the weaknesses of the Europeans, which prevent their cultivation in America, crop out. Hybrids in which the *vinifera* blood is more attenuated, as secondary or tertiary crosses, give better results.

Several secondary hybrids now rank among the best of the cultivated grapes. Examples are the Brighton and the Diamond. The first is a cross between Diana-Hamburg, a hybrid of a *vinifera* and a *labrusca*, crossed, in its turn, with the Concord, a *labrusca;* the second is a cross between Iona, also a hybrid of a *vinifera*, and a *labrusca* crossed with the Concord. Both were grown from seed planted by Jacob Moore, of Brighton, New York, in 1870. The Brighton was the first secondary hybrid to attract the attention of grape-breeders and its advent marked an important step in breeding grapes.

The signal successes achieved by the hybridizers of the European grape with the native species quickly led to similar amalgamations among the American species. Jacob Rommel, of Morrison, Missouri, beginning work about 1860, hybridized the *labrusca* and *riparia* grapes

so successfully that a dozen or more of his varieties are still cultivated. All are characterized by great vigor and productiveness, and, though they lack the qualities which make good table grapes, they are among the best for wine-making. Rommel has had many followers in hybridizing the native species, chief of whom is Mr. T. V. Munson, Denison, Texas, who has literally made every combination of grapes possible, grown thousands of seedlings, and produced many valuable varieties.

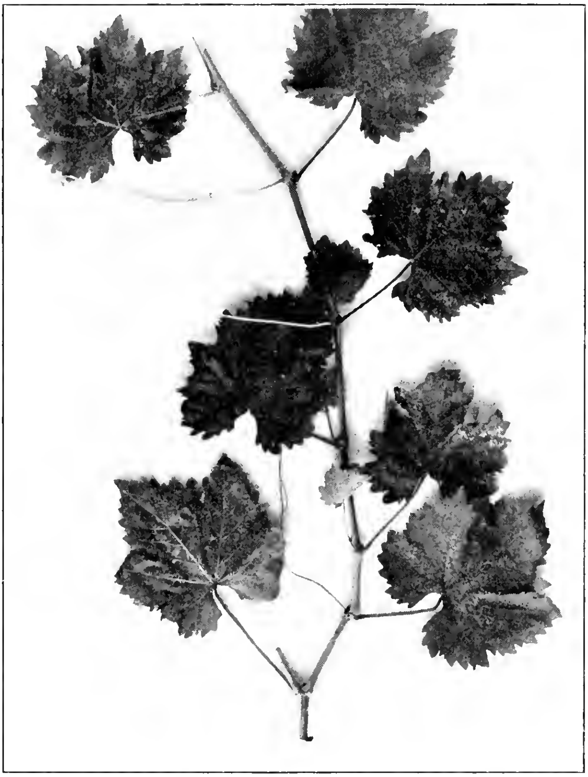
The aim of hybridization in breeding plants is to combine the desirable and eliminate the undesirable characters of varieties or species in a new race. A plant, however, is such a complex sum-total of characters that no one can predict with any certainty the result of mingling the characters of two more or less distinct plants. Speculation thus quickens the charm of hybridization. The progeny of crossed grapes is always chaotic and must be passed through the sieve of selection, the meshes of which have grown larger and larger with use until now out of thousands of new forms a grape-breeder will retain few indeed.

Within the last decade, hybridizing has received a great impetus through the publication of Mendel's experiments. In the past hybridization has been a maze in which breeders lost themselves. Mendel's discovery in heredity assures a regularity of averages and gives a definiteness and constancy of action hereto wholly unknown in hybridization. It now appears that many of the characters of grapes follow

SHOOT OF *Vitis æstivalis*, THE SOUTHERN WINE GRAPE.

the law discovered by Mendel, and with this as a solid basis and the brilliant methods of Mendel for example, the further domestication of the species of this fruit ought to go forward in leaps and bounds.

Selection, continued through successive generations, so important in the improvement of field and garden plants, can play but small part in the domestication of the grape. The period between planting and fruiting is so long that progress would be slow indeed were this method



Shoot of *Vitis vinifera,* the European Grape.

relied upon. Moreover, selection, as a method in breeding, is possible only when plants are bred pure, and it is the experience of grape-breeders that in pure breeding this fruit loses in vigor and productiveness and that the variations are exceedingly slight and unstable. Many pure-bred grapes have been raised on the grounds of the New York Agricultural Experiment Station under the eyes of the writer, of which very, very few have surpassed the parent or have shown promise for the practise of selection.

From present knowledge it does not appear probable that new characters are produced in plants by hybridizing. New varieties so origi-

nating are but recombinations of the characters in the parent—the combination is new but not the characters. Thus one parent of a hybrid grape may contribute color, size, flavor and practically all of the characters of the fruit and the other parent vigor, hardiness, resistance to disease and in general the characters of the vine. Or, of course, these and the other items in the make-up of the grape may be intermingled in any mathematically possible way. New characters probably appear as variations, and of these plant-breeders now recognize two kinds.

Nothing is more certan than that all offspring differ from their parents in many details—individual variation. Plant-breeders have long believed that by selecting desirable variations we have an efficient means of improving plants just as evolutionists have held and many continue to hold that evolution goes forward by means of natural selection from these variations. But there is a new school, headed by the Dutch botanist, De Vries, who believe that these variations do not produce anything new, but that they always oscillate around an average, and if removed from this for a time, they show a tendency to return to it. Whether the orthodox Darwinians or the De Vriesians are right does not matter here. The point is that the fluctuating variations of individuals, upon which Darwin chiefly founded his principle of natural selection, cut but a small figure in the breeding of grapes. It is not certain that such variations are heritable, nor whether they are capable of cumulative increase generation after generation, and, besides, as we have seen, selection must be consistent and persistent for too long a while to make it effective with grapes.

Evolution and plant-breeding have taken a fresh start through the recent amplification by De Vries of the theory that marked changes take place in plants through mutations, or characters which arise in a plant at once, with a single leap, and are stable from the time they arise. If this theory hold for grapes, it may be that there is a possibility of absolutely new characters arising in this fruit. It is well known that bud-sports, which in most cases must be called mutations, now and then arise in grapes. But these mutations have not as yet played an important part in producing new varieties. Not more than two or three of the fifteen hundred sorts now under cultivation are suspected of having arisen in this way. Until the causes of these mutations are known and they can be produced and controlled, but little can be hoped for in the amelioration of grapes through mutations.

Hybridization, then, has been and continues to be the chief means of domesticating grapes. "Fluctuations" and "mutations," produced other than by hybridizing, are too vague as yet for the grape-breeder to lay hands on. Even should the theory of De Vries be true, that nothing new—in the strict sense of the word—comes except through mutations, with more than a score of species of grapes, each with manifold distinct characters, all capable of fluctuating variations, there are many

surprises in store for lovers of grapes in the new varieties that may be produced by hybridizing.

Whatever method of improvement is followed very much depends upon the immediate parentage. Some varieties, whether self-fertilized or crossed, produce much higher averages of worthy offspring than others. There is so much difference in varieties in this respect that to discover parents so endowed is one of the first tasks of the grape-breeder. Unfortunately, no way is known of discovering what the best progenitors are except by records of performance. The reasons for this prepotency, seemingly well established in plants and animals alike, are not well explained by present knowledge. Often varieties of high cultural value are worthless in breeding because their characters seem not to be transmitted to their progeny, and to the contrary a variety good for but little in the vineyard may be most valuable from which to breed.

What are the results of a century's work in domesticating the wild grapes of America?

There are approximately in eastern America at the present time 240,000 acres of grapes, the product of which is largely sold for dessert purposes, but from it is manufactured yearly in the neighborhood of 10,000,000 gallons of wine, of which about 1,000,000 gallons are champagne. The making of grape juice, an industry possible only with native grapes, has grown so rapidly that it is hard to estimate the output, but certainly not less than 2,000,000 gallons were sold in the markets last year. It is doubtful if any other cultivated plants at any time in the history of the world has attained such importance, in so short a time from the wild state, as our native grapes.

Fifteen hundred varieties from twelve of the native species of grapes are now under cultivation. Almost every possible combination between these species has been made; they have been so mixed and jostled that species can no longer be recognized in the majority of varieties and the future breeder must work with characters rather than species. The methods of the past in domesticating the native grapes have been wholly empirical and extremely wasteful. Many have been called, but few chosen. But with the new knowledge of breeding and with the experience of the past, domestication ought to proceed with greater certainty. It is not too much to say that in this immense country, with its great differences in environment, we shall, some time, everywhere be growing grapes and of kinds so diverse that they will meet all of the purposes to which grapes are now put and the increasing demands for better fruits made by more critical consumers.

UNITED STATES PUBLIC HEALTH SERVICE[1]

By ALFRED C. REED, M.D.

ASSISTANT SURGEON, UNITED STATES PUBLIC HEALTH SERVICE

THE wide-spread ignorance of the various means employed by the federal government to promote the well-being of its citizens is nowhere better exemplified than in the common ignorance of the functions and important work of the Public Health Service. This ignorance is the more lamentable inasmuch as the Public Health Service is the sole national agency operating to combat and prevent epidemic diseases among human beings, and to improve public sanitation and hygiene. in the United States. The awakening national conscience in public health affairs lends peculiar interest at this time to a consideration of the varied and important functions exercised by this service, and the fascinating history of its achievements.

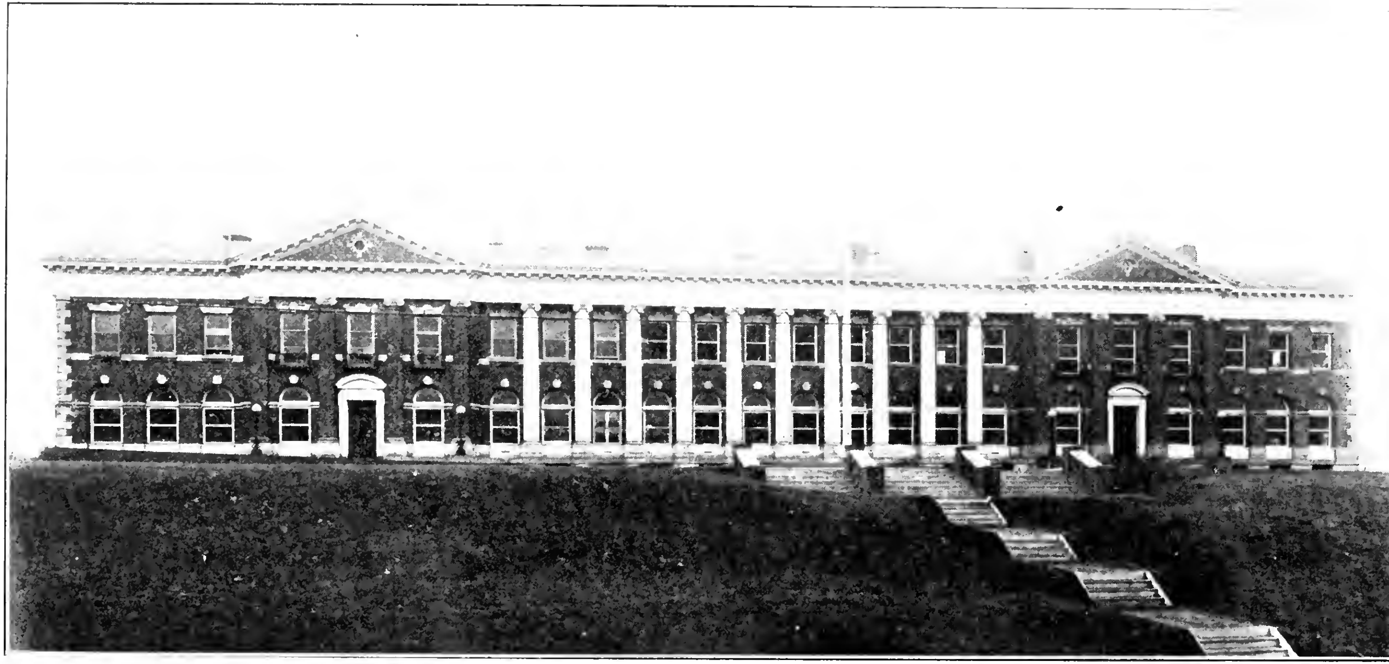
The Marine Hospital Service is one of the oldest and most peculiarly American of all our institutions. Its beginning was in an act of congress of July 16, 1798, which put a tax of twenty cents a month on every seaman of the United States, to be taken from his wages. The occasion for this procedure had been well explained by Hon. William Williamson in the House of Representatives away back in 1792.

> Wherever it is probable that sailors may be sick, there I would make provision for their support and comfort. Hospitals should be erected or lodgings hired at every port of entry in the United States, for sick and infirm seamen, where they may be properly attended during their indispositions. The money to be collected at the several ports as hospital money should be expended in those same ports alone, under care of such a person as may be designated for that purpose.

The first hospital owned by the government was at Washington's Point, Norfolk County, Virginia. This was purchased in 1800. Three years later a Marine Hospital was completed at Boston. At about the same time, the money collected by taxation of seamen was transformed into a general fund for medical relief work among sailors. The same legislation made provision for the establishment of the service in New Orleans, which was not then a part of the United States.

After a time the seamen's tax was not sufficient to maintain the constantly broadening work, which had to be correspondingly restricted in its usefulness. No chronic or incurable diseases were treated, nor was any patient kept longer than four months. Sailors in those days fared poorly, and their life was a hard one indeed. Especially was this true on the Mississippi River system, which was a great water-highway

[1] The author is indebted to Surgeon George W. Stoner, Chief Medical Officer at Ellis Island, for many facts concerning the earlier history of the Public Health and Marine Hospital Service.



Hygienic Laboratory, U. S. Public Health Service, Washington, D. C.

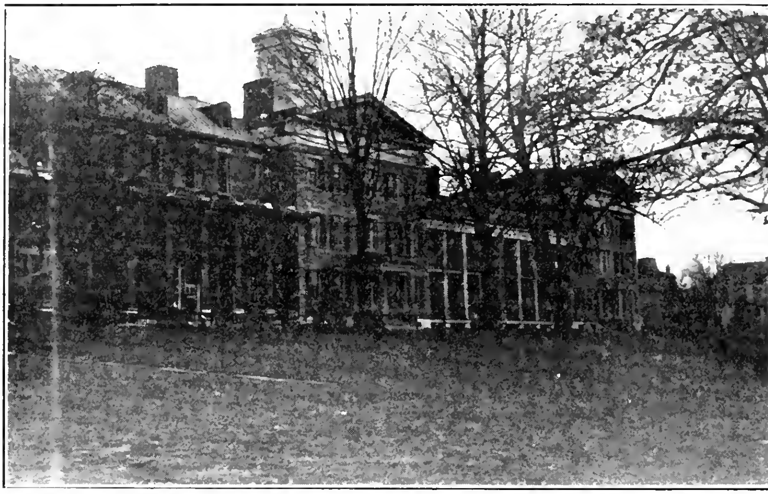
and the principal means of commerce and communication over a vast territory. Often a flatboat starting from the upper river would lose its entire crew of five or six men by disease before reaching New Orleans. During the severe cholera epidemic of 1832 and 1834 the lot of the rivermen was especially severe.

It became necessary for congress to assist the service work by annual appropriations. In 1837 the original Marine Hospital was built in New Orleans and provision was made for purchasing sites for hospitals in three inland zones. Along the Mississippi River stations were located at Natchez, Miss.; Napoleon, Ark., and St. Louis, Mo. On the Ohio, the chosen points were Paducah, Louisville and Pittsburgh. The center for the Lake Erie sailors was at Cleveland. The first Marine Hospital at Chicago dates from 1848 and was built on land adjacent to old Fort Dearborn. The second hospital, the present one, was authorized in 1864 and opened for patients in 1873. It occupies a beautiful location on the lake shore five miles north of the harbor.

The first service establishment on the Pacific Coast, at San Francisco in 1851, was on the contract basis. A hospital was erected three years later, a commodious and well-built structure, doomed to serious injury in the severe earthquake of 1868. The contract system with other hospitals was then resumed and continued until the completion of the present building in 1875. During the Civil War many marine hospitals in both the north and the south were converted into military hospitals. Those at Boston and Norfolk were used in this capacity in the war of 1812.

In 1870 congress reorganized the service and Dr. John M. Woodworth, of Illinois, was appointed supervising surgeon. Within the next three years, the service began to attract considerable attention in foreign countries. London medical journals bestowed lavish praise on this uniquely American institution. At this time service officers were requested by the supervising surgeon to inform themselves fully as to local health regulations and to assist, when requested, in their enforcement.

Upon Dr. Woodworth's death in 1879 President Hayes appointed Dr. John B. Hamilton to succeed him. The year before Dr. Woodworth's death marked the occurrence of a terrible epidemic of yellow fever in the Mississippi Valley. With this freshly in mind, congress added quarantine control to the growing functions of the Marine Hospital Service, but failed to make any appropriation for its operation. Then a year later, in 1879, a law was passed creating a National Board of Health to exercise quarantine functions for four years. At the end of that period, the law of 1878 was revived, and national quarantine passed permanently into the hands of the Marine Hospital Service. The entire development of the quarantine service took place under the wise guidance of Dr. Hamilton.



Marine Hospital, Staten Island, N. Y.

In June, 1891, Dr. Hamilton resigned to be succeeded, by the appointment by President Harrison, of Dr. Walter Wyman, who had been chief of the quarantine division in the administrative bureau. In 1902 the enlarging and changing functions exercised, necessitated a change in name from the old Marine Hospital Service to the cumbersome but expressive Public Health and Marine Hospital Service. In 1893 additional quarantine powers were added and additional responsibilities imposed, such as the medical inspection of immigrants. In 1875 the supervising surgeon became the supervising surgeon general, and was commissioned. By the legislation of 1889 commissions were conferred on all the regular officers of the corps. The old seamen's tax was finally abolished in 1884 and since then the service has been supported entirely by Congressional appropriation.

Examinations are held annually at Washington for candidates for admission to the corps. No more rigorous test is to be found for any medical appointment than this, lasting from a week to ten days or more. The examination covers the physical condition, literary and academic preparation, and practical and theoretical training. It includes a practical laboratory and hospital bedside examination. After four years assistant surgeons are eligible to be examined for promotion to the next grade of passed assistant surgeon. After from fifteen to twenty years' service, further examinations are held for promotion to the grade of surgeon. There are now 135 commissioned officers. This service offers one of the most attractive openings in the country for young physicians.

The splendid institution known as the Hygienic Laboratory, now recognized the world around for its excellent contributions to the knowledge of scientific medicine and of public health and sanitation,

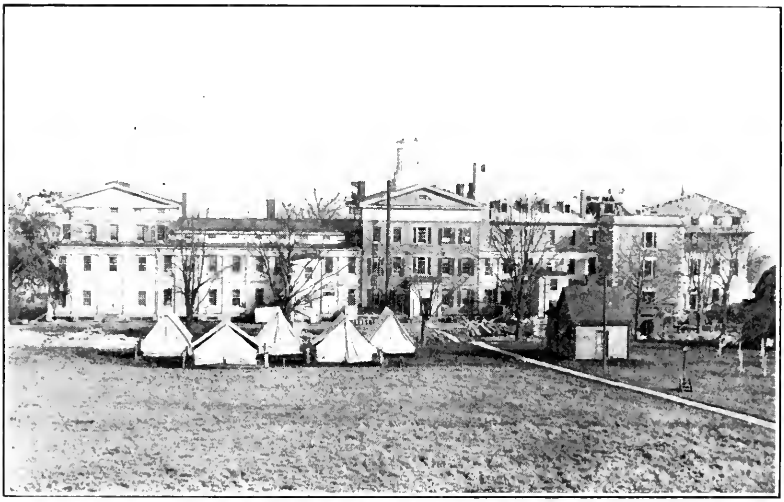
was founded just twenty-five years ago as a laboratory of pathology and bacteriology in the old marine hospital at Stapleton, Staten Island. At first all of the work was done by one officer in the intervals of his attendance in the hospital wards. After four years the work was transferred to Washington, where it has been ever since, and until 1894 was housed on one floor of the service office building. About this time the advantages began to be realized of using this laboratory as a training school for officers, supplemented with details abroad affording opportunity for visiting the great centers of London, Paris, Berlin, Vienna and other cities.

Among the earlier subjects taken under consideration were disinfecting methods as applied to quarantine and epidemic practise. These investigations resulted in the elaboration of a system of disinfecting apparatus, together with disinfecting agents and a method for their application, which now stands unrivaled. This laboratory was probably the first to recommend formaldehyde in place of the older disinfectants, steam, carbolic acid and sulphur dioxide. The first authoritative publication on the use of diphtheria antitoxin was issued by the Marine Hospital Service, and the first diphtheria antitoxin made in the United States was produced in the Hygienic Laboratory. Both resulted from personal instruction received by an officer from Behring and Roux, who had separately announced their discovery at a meeting of the International Congress of Medicine at Budapesth.

In March, 1901, congress appropriated $35,000 for the necessary buildings, and directed the cession of five acres of land from the old naval observatory site by the secretary of the navy for the use of the Hygienic Laboratory. After the legislation of July, 1902, which increased the functions of the Marine Hospital Service and changed its name to the Public Health and Marine Hospital Service, the scope, or-

CHICAGO MARINE HOSPITAL.

ganization and personnel of the laboratory were greatly extended. An advisory board was created, consisting of officers from the Army and Navy Medical Corps, a scientist from the Bureau of Animal Industry of the Department of Agriculture, and five men from civil life, who were to be skilled in laboratory work bearing on public health problems. These five at present are Victor C. Vaughan, dean of the School of Medicine of the University of Michigan; William Welch, professor of pathology at Johns Hopkins University; Frank Wesbrook, professor of pathology at the University of Minnesota; Simon Flexner, of the Rockefeller Institute; and William T. Sedgwick, professor of biology at the Massachusetts Institute of Technology.



Rear of Stapleton Marine Hospital, showing Tents for Tuberculosis Patients.

Three additions were made to the original divisions of pathology and bacteriology. These were medical zoology, chemistry and pharmacology. Medical zoology embraces the study of parasitic diseases of man. Under pharmacology, drugs are examined as to purity, potency and action, and important work is done on the standardization of drugs. By another act of July, 1902, provision was made for the licensing of all establishments engaged in interstate traffic in viruses, serums, toxins, antitoxins and analogous products. Samples of such products are bought in the open market and tested for purity and strength. The manufacturing establishments are inspected by medical officers, both before and after the license is granted. Fines and suspensions or withdrawal of license are the penalties for false labeling or faulty methods of production.

The laboratory makes a practise of assisting health officers of states and communities which have no reliable laboratory facilities, by analyzing samples of water, as to impurities, infection and potability. In-

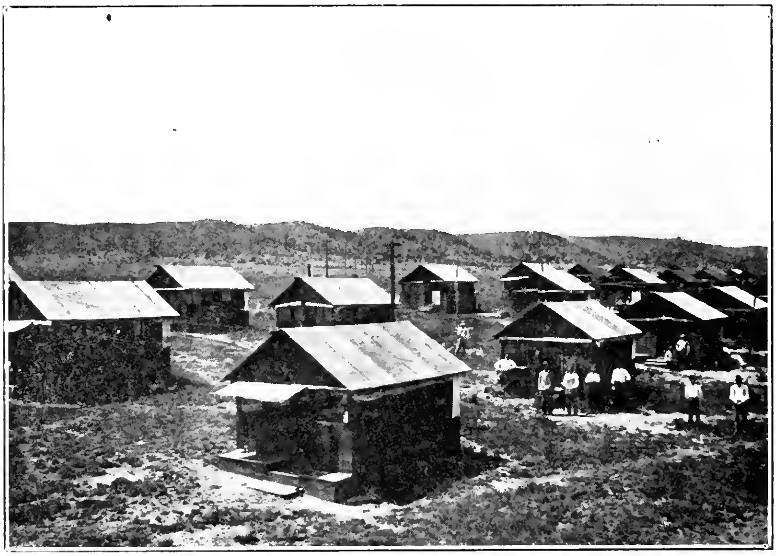
vestigation has likewise been made of the hygiene and sanitary arrangements of railroad coaches and sleeping cars. The question of the dissemination of malaria by mosquitoes has been another productive field of research.

Closely connected with lines of work already outlined, is that of the leprosy investigation station on Molokai, Hawaii. Here, with unlimited material at their disposal, the director and his able assistants are making careful studies of the lepra bacillus, with the ultimate ambition of producing some means for the prevention and cure of the disease. A good example of the thorough and painstaking study of epidemic disease which characterizes the service work, is the exhaustive research made by Stiles of the distribution and results of hookworm infection in the south and especially in the rural sandy districts of Georgia and Florida. What Stiles did for the south, Ashford and King did for Porto Rico, and the result has a large economic, social and sanitary value in both places.

Relief stations of the service are divided into four classes. The first-class stations, numbering 23, consist of a marine hospital under the command of a commissioned officer. Among these is included the tuberculosis sanatorium at Fort Stanton, N. M. After the subjugation of the Apache Indians, the old army post at Fort Stanton, which for forty years had been a frontier protection for ranchmen, was no longer necessary, and in 1896 it was abandoned. For three years the post was deserted, except for the wild desert prowlers, and sagebrush and decay replaced the busy military life which had known it so long. In 1899 the property was acquired by the Public Health and Marine Hospital Service, and again the martial spirit took possession, and once more the stars and stripes floated over the parade ground, fanned by the health-bearing breeze of the New Mexican plateau. But the foe to be conquered under the new régime was not the fierce red warrior whose merciless and invincible spirit had been supreme against the Spaniard and the American for three hundred years. The new foe, more deadly and terrible by far than the old, was the silent and merciless white death, the relentless destroyer of thousands, the plague of tuberculosis.

In situation Fort Stanton is admirably adapted to its present purpose. At an altitude of 6,200 feet, it has winter snows, and moderate heat in the summer. The reservation includes about forty-five square miles, and has resources which, when fully developed, will go far toward making the institution self-supporting. Natural water power is available. Two thousand cattle can be pastured on the range, which now supports almost that number of beef cattle, besides a large dairy herd. Poultry raising will soon supply an abundance of turkeys, chickens and eggs, and hog raising is another industry which promises much.

The daily number of patients averages about two hundred, under the care of seven medical officers. Sixty attendants find employment



TUBERCULOSIS CAMP

on the reservation. No unimportant function of the sanatorium is that which finds its result in the influence of the education in hygiene and tuberculosis prevention, upon those who leave after having been cured or benefited by the treatment. These men spread their new-found knowledge among their associates and so extend the actual good accomplished.

Patients come to Fort Stanton largely from sailor boarding houses and other crowded districts of the large sea ports. Some are old incurable cases, but their lives are prolonged and made more comfortable, and incidentally the Sanatorium is in effect a quarantine station, not in restraining men from liberty, but in that it keeps from the large centers of population a daily average of over two hundren consumptives who in all probability would have continued as sources of infection to innumerable others.

Over half the cases admitted have been returned to active life either cured or near enough cured to resume their occupations.

Outside of Fort Stanton, the larger marine hospitals are located in New York, Chicago, San Francisco, Boston, Detroit, Buffalo and New Orleans.

The second-class stations are under the command of commissioned officers, but have no hospital accommodations of their own. Patients are kept in private or other hospitals, under the exclusive professional care of the medical officer, and the government pays for the hospital facilities under a definite contract. Third-class stations are under the charge of contract acting assistant surgeons, and patients are cared for under government contract with local hospitals. All other relief stations come under the fourth class. Certain of these have a contract surgeon in charge, but have no hospital facilities available. and the

FOR SUMMER, FORT STANTON.

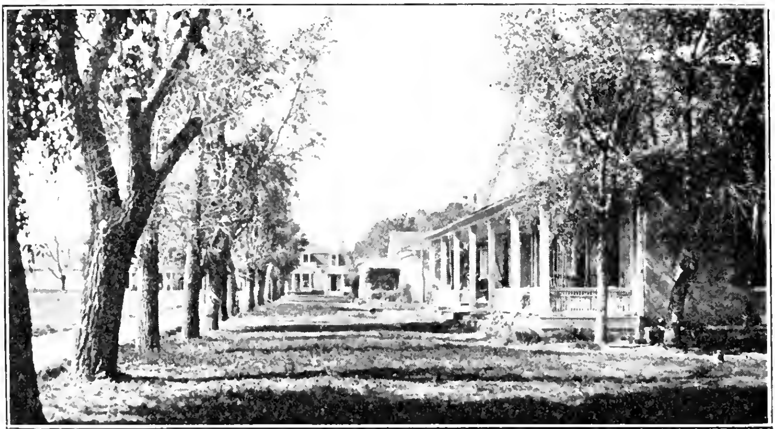
functions of the others are exercised by the Collector of Customs at the place.

Persons entitled to the benefit of medical relief from the Public Health Service are those employed on board in the care, preservation or navigation of any registered or licensed vessel of the United States, or in the service on board of any so engaged.

Officers and crews of vessels in the service of the Mississippi River Commission are included with those entitled to marine hospital relief. This commission has to do with the engineering and inspection of the Mississippi levees, and the removal of snags and obstructions to shipping. Its concern is to maintain the navigability of the Mississippi and its larger branches.

The Revenue Cutter Service, the Army Engineering Corps, together with keepers and surfmen of the Life-Saving Service, are all beneficiaries, as well as the men of the Light House Service, including light ships. A provision not generally known is that foreign seamen may utilize the Marine Hospital accommodations, if written security is given for the payment of the small fees fixed by the department, by the master of the vessel or the consul of the nation under whose flag the vessel sails. In the year ending June 30, 1911, a total of 52,209 patients were treated at the various relief stations of the service, of whom 15,442 received hospital care. At the Fort Stanton Sanatorium, 322 consumptive patients were under treatment.

A large number of physical examinations of seamen in the various government services are necessary, as of candidates for entrance, for promotion and for retirement. Such examinations are conducted by



OFFICERS' QUARTERS, FORT STANTON, NEW MEXICO.

Marine Hospital Service officers for the Revenue Cutter, Coast-Survey, Life-Saving and Lighthouse Services. Instruction is given, when properly applied for, in methods of resuscitation of persons apparently drowned. Applicants for a pilot's license are examined as to their hearing, color perception and visual acuity. The total of such physical examinations for the last fiscal year was 4,610.

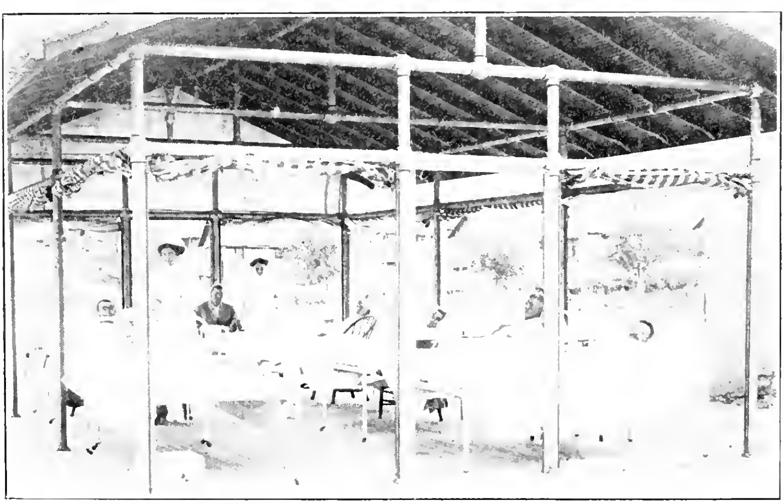
There are many foreign details filled by service officers besides their varied and extensive activities at home. The American consulates have medical officers attached in Yokohama, Habana, Guayaquil, Naples and Hong Kong. Contract surgeons are kept at the principal ports of China, Russia, Japan, India, Italy, Mexico and tropical America. Eight United States Revenue Cutters have a medical officer on board. Through all these various and widely separated posts, information is constantly being collected and collated as to health conditions all over the world. This information is issued in the Public Health Bulletins published weekly by the Bureau of the Public Health Service in Washington. Service officers are detailed to attend certain congresses and conventions on scientific and medical lines, in this country and abroad, and many exhibits are prepared for scientific and popular conventions, of an educative nature and illustrative of the service work.

No more important feature of national health protection can be named than the quarantine service. The history of quarantine measures takes us back to the time of the Milanese and Lombardians, late in the fourteenth century. At that period the great and lucrative Italian commerce had been responsible for the introduction of the black plague from the Levant into Europe and terrible fear was on all the people. Persons coming in with the plague were taken into the midst of large fields and left alone to recover or die as best they could. The penalty for disobedience of the stringent rules was death and confiscation of the victim's property. In 1475 Venice established a Sanitary

Council of three nobles, who were directly charged with preventing the entry of epidemic disease. The Council constructed lazarettoes on two islands, and instituted a rigid inspection of incoming crews, and the letters of health from the place of departure. The time of detention was forty days (quarante diei), hence our term quarantine. Venice was therefore the first to practise systematic quarantine. Similar arrangements were adopted by other countries, and have developed into our modern institution of quarantine. The first quarantine disregarded humane and medical considerations, for the sake of commerce. The latest quarantine disregards commerce but only if it stands in the way of public health and real humanity.

Quarantine stations are maintained at forty-five points of entry into the United States, besides eight stations each in Hawaii, Porto Rico and the Philippines. The quarantine control of the Canal Zone is also exercised by the Public Health Service. A fully equipped quarantine station has adequate provision for boarding and inspecting vessels, apparatus for mechanically cleansing them, and suitable equipment for disinfection with steam, sulphur, formaldehyde and various solutions. It must include a clinical laboratory, hospitals for contagious and doubtful cases, a steam laundry, detention barracks for suspects, bathing facilities, a crematory, sufficient supply of good water and a proper system for the disposal of sewage.

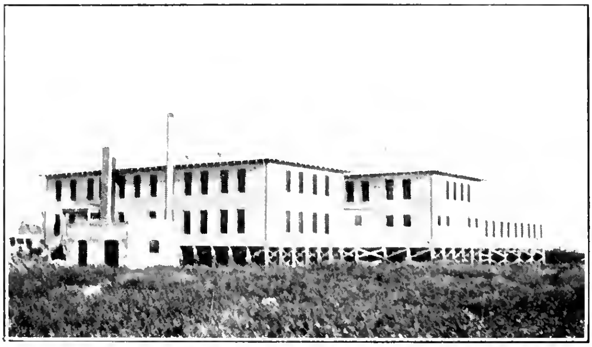
Vessels from domestic ports are also subject to quarantine, if quarantinable disease prevails in the port of their departure, or if there is sickness on board. No persons other than quarantine and customs officers, and pilots, are permitted to board vessels subject to quarantine, until they have been given free pratique. In case a vessel carrying immigrants develops quarantinable disease in transit, after



Bed Shelter, Hospital Annex, Fort Stanton.

the full quarantine regulations have been satisfied, the health officers of the several states to which the immigrants are bound are notified of the circumstances that they may keep close supervision to detect any later development of the disease.

Those vessels are placed in quarantine which have had quarantinable disease on board in transit or which the inspecting officer considers to be infected, also vessels arriving during the summer months from tropical American ports, which are not known to be free from yellow fever. Vessels in quarantine may have no direct communication with any person or place outside, and no communication of any nature except



Immigration Station, Pelican Island, Galveston, Texas.

under the supervision of the officer in charge. The persons detained from such a vessel are divided into small isolated groups, and inspected twice daily by the physician. No intercourse is allowed between these groups. No convalescents are discharged from quarantine until free from infection, and whenever possible this is determined by bacteriological examination.

The United States quarantine regulations provide for inspection of but six diseases, yellow fever, typhus fever, bubonic plague, leprosy, smallpox and cholera. A few facts relative to these will make plain the nature of the special precautions necessary to exclude them.

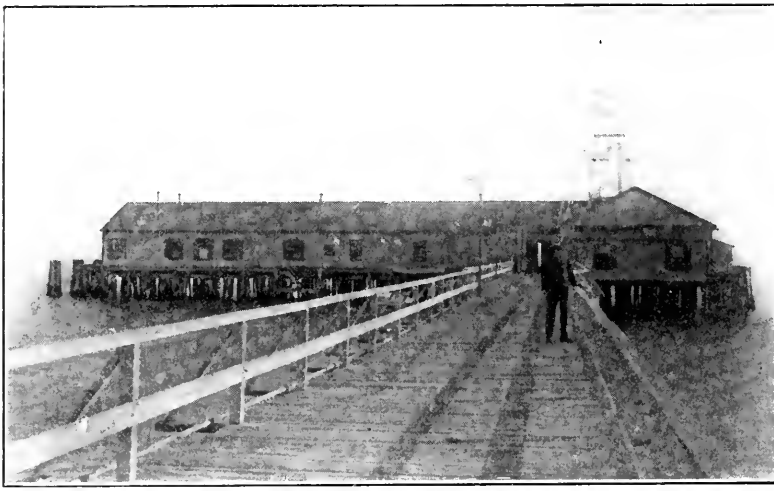
Yellow fever is the great sanitary curse of the tropical Americas. It is an acute non-contagious fever of unknown causation. Its extreme fatality is shown by a death rate which varies from 1 to 95 per cent. The causative agent, whatever it may be, is found in the patient's blood and is transferred to others by one agency alone, a certain type of mosquito, *Stegomyia fasciata*. The area where yellow fever is endemic corresponds exactly with the geographical distribution of the *Stegomyia*. It was due to the magnificent work of the Army Yellow Fever Commission in Cuba in 1898 that responsibility for the spread of the disease was definitely laid to the rôle of this mosquito. Too much honor can not be paid to those brave physicians who risked their lives to discover a

means of checking this yellow scourge and above all to Drs. Walter Reed and Lazear, whose lives helped to pay the price for the knowledge which finally vanquished yellow fever. Their associates on the board, Drs. Carroll and Agramonte, as well as Dr. Finlay, of Havana, are no less deserving of praise. The work of the Army board completed the excellent pioneer work of Surgeon Henry R. Carter on the incubative period of yellow fever. It follows that yellow fever can only be successfully combated by destruction of the mosquitoes by means of which it spreads. Quarantine measures against the disease are therefore concerned with isolation of all cases and very careful exclusion of every possible contact with mosquitoes by screening and elimination of all breeding places.

Cholera presents an entirely different picture from the standpoint of quarantine. Here we have a disease proved to be caused by an intestinal infection with a definite and characteristic microbe, the so-called "*comma*" *vibrio* of Koch. The infection is limited absolutely to the intestinal tract, consequently the entire danger of spread of the disease is limited to the alvine discharges. The bacteria are taken into the system chiefly through the ingestion of infected drinking water, the contamination having arisen from sewage infection or other polluting contact with infected intestinal discharges. Uncooked vegetables and fruits are a secondary source of danger for like reasons. Preventive measures must also be extended to exclude articles of diet such as fresh fruits, for instance, which may tend to excite a tropical diarrhea and so produce a point of lowered resistance where the cholera germs can take effect. Quarantine measures, therefore, aim to isolate all frank cases and suspects, and to detain all who have been exposed, in small groups under close observation for at least five days, covering the incubation period of cholera. Water and food supply must be above suspicion of carrying the germs, and strict cleanliness of person and quarters must be strictly enforced. It is absolutely essential that intestinal discharges from frank cases and suspects alike be thoroughly disinfected. Before convalescent cases are released from detention the intestinal discharges must be proved free from cholera germs by microscopical examination and bacteriological culture.

Smallpox is more familiar than the diseases just described, as are also the circumstances embodied in its quarantine control. Vaccination or proof of immunity by having had the disease are required of all persons exposed, which, of course, means all on board an infected vessel.

Typhus fever, the old time "ship" or "famine" fever, is very rare now in the United States, probably because of improved ship hygiene and sanitation, conditions always inimical to the disease. The last epidemics in this country were in Philadelphia in 1883 and in New York in 1891–92. Very rarely is a case seen at quarantine, but it is controlled by isolation, and disinfection of articles and quarters exposed to infection. Drs. Anderson and Goldberger, of the Hygienic Labora-



Disinfecting Wharf, Tampa Quarantine Station, Florida.

tory, have recently proved the identity of typhus and "Brill's disease," a disease fairly often seen in large cities. They have also shown the rôle of the body louse in transmitting typhus. The isolation period for suspects is fourteen days.

No more terrible epidemic has ever threatened this country than bubonic plague and against the entry of no disease are more rigid precautions taken. It exists constantly in oriental countries, especially in China and India, and the great danger of introduction here always confronts us. There are several forms of plague, of which the pneumonic type is the most deadly. This was the prevailing type in the recent epidemic in northern China. The bacillus of plague lives and multiplies in the blood of the victim. It also causes an epizootic in rats and certain other rodents, and from these, as well as from human cases, the bacilli are carried to human victims through the agency of fleas and bedbugs. In addition pneumonic plague is highly infectious directly, spreading from man to man by aerial convection. It is very easily seen how important is the eradication of plague epizootic among rats, ground squirrels and other rodents as is being done now in California. An epizootic is a powder magazine waiting only for the match of proper local conditions to explode in all directions in an epidemic of the greatest virulence.

Quarantine measures against plague first of all aim to prevent infected cargo, baggage or ballast from being shipped. To this end rat guards are used, all suspicious articles going on the vessel are thoroughly disinfected and special efforts are made to destroy all rats on board. Cases of plague reaching a domestic quarantine station are isolated and the surroundings and belongings thoroughly disinfected.

A period of fifteen days must elapse after the last possible exposure before release of suspects.

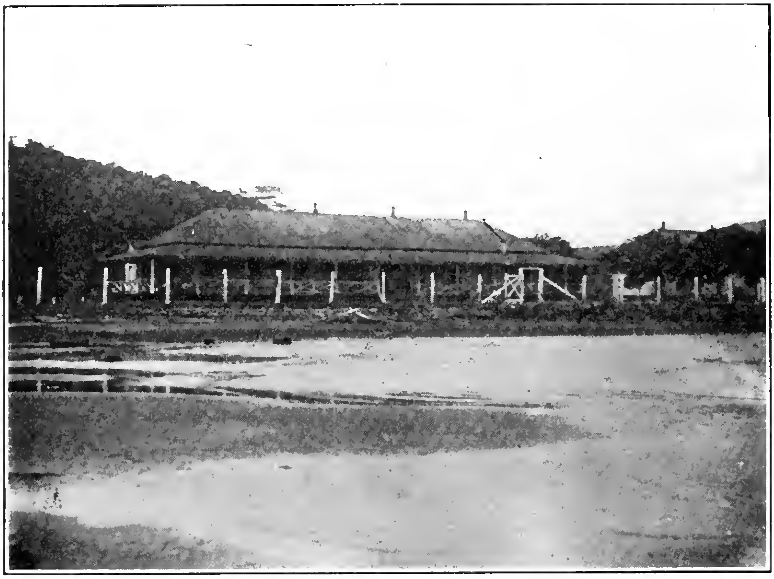
Leprosy is only mildly contagious, at least in this country, and is an instance of a disease made quarantinable more because of its loathsome nature and the abhorrence in which it is popularly held than because of actual infective danger from it. The immigration law absolutely excludes all alien lepers. Others must be removed from vessels at quarantine, and the quarters disinfected.

No small feature of the activity of the Public Health Service is its conduct of the medical examination of immigrants. No argument is necessary to convince every thoughtful patriot of the vital importance of this work. The immigration laws are explicit, and while the medical examiners have no authority to pass judgment on the admissibility of aliens, they have the basic function of supplying medical evidence against mental and physical defectives, which evidence under the law has a determining influence with the inspectors of the Immigration Bureau of the Department of Commerce and Labor. The methods of medical inspection of incoming aliens and laws concerned, have been discussed and described by the author elsewhere,[2] and will not be taken up here.

By far the largest port of entry for immigrants is through Ellis Island, N. Y. During the year ending June 30, 1911, 749,642 aliens were inspected there, as against a total of 303,007 for all other points of entry combined. At Ellis Island are stationed 23 medical officers,

QUARTERS AT TAMPA, FLA.

[2] "Medical Aspects of Immigration," THE POPULAR SCIENCE MONTHLY, April, 1912; "Going through Ellis Island," THE POPULAR SCIENCE MONTHLY, January, 1913.



DETENTION BARRACKS, MARIVALES QUARANTINE, PHILIPPINE ISLANDS.

and a larger force would be able to do even better work. The immigrant hospital on Ellis Island during the year mentioned cared for 5,141 aliens, in addition to 720 cases of acute contagious disease which were transferred to the State Quarantine Hospital at the entrance to the harbor pending completion of the present excellent contagious disease hospital on Ellis Island. There is possibly no place in the United States where a similar variety of interesting and unusual cases can be seen as at the Ellis Island Immigrant Hospital. Drawn from every race, nation and climate, one can see there all the usual varieties of disease and, in addition, peculiar tropical affections, unusual skin lesions and obscure internal disorders of the most diverse description. This hospital is excellently conducted and reflects credit on the professional skill of the officers in charge, as well as being a godsend to the immigrants who constitute its sole source of patients.

Next to Ellis Island the larger immigration points are Boston, with 45,865 entries; Philadelphia, with 45,023; Baltimore, with 22,866; and then San Francisco, Galveston, Seattle, Honolulu and Tampa. Medical examination of incoming aliens is conducted at forty-five points besides the preliminary advisory inspections made by medical officers detailed to consulates in foreign countries.

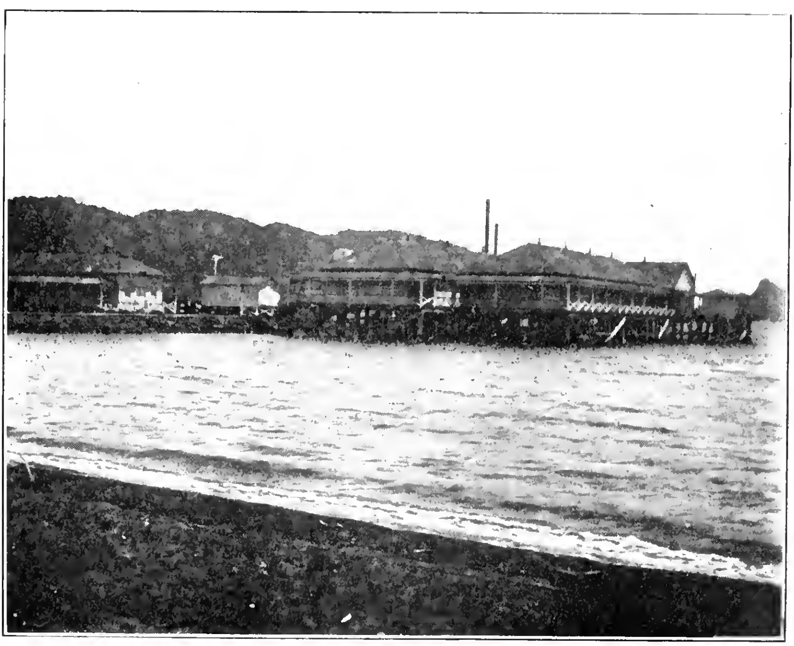
The annual report of the surgeon general for the last fiscal year contains an account of many valuable and interesting lines of investigation conducted by service officers. One of the most notable achievements was the transmission of measles from man to monkeys, the first time this has ever been accomplished. Contrary to the erroneous pop-

ular belief, measles is one of the most fatal of common diseases, largely because of complications. Ability to produce it experimentally in animals opens the way for the discovery of the causative agent, as well as of a curative or prophylactic serum.

Assistance has been given to the Bureau of Chemistry of the Agricultural Department by officers of the Hygienic Laboratory in the scientific investigation of certain food products, and in giving testimony in court in trials arising under the Pure Food and Drugs Act. About one hundred proprietary medicines have been examined as to composition, strength and action.

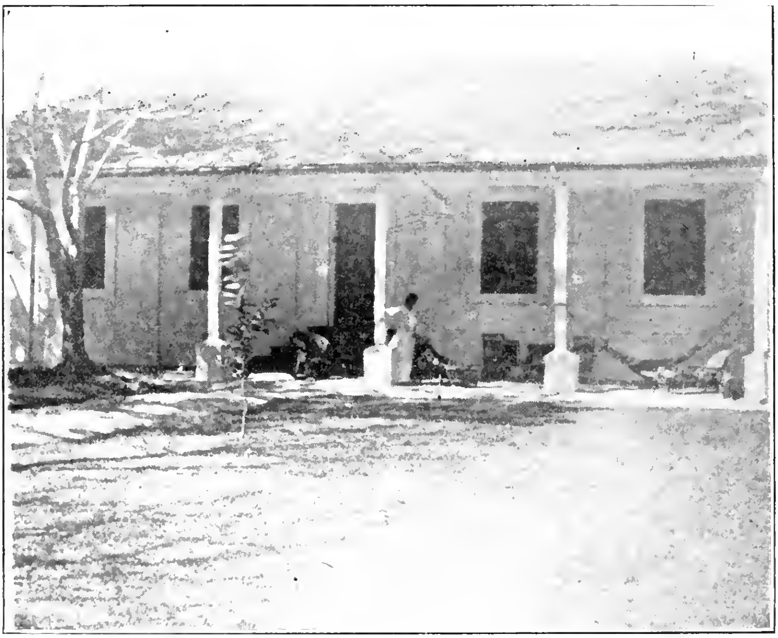
Treatment for rabies was successfully administered to 128 persons, and 777 treatments were sent out into 14 different states. Examinations are made at the Hygienic Laboratory for tuberculosis in government employees. At the request of state authorities, officers have been detailed to determine the cause of the prevalence of typhoid fever in several states. A sanitary survey has been made of towns bordering on Lake Erie and the Niagara River and the work is being continued on all of the Great Lakes to collect data relative to their contamination with typhoid germs. The results will be applied directly to the prevention of sewage pollution, and the conservation of a pure water supply in those communities dependent for their supply on the Great Lakes.

Much work has been done on the subject of pellagra and patients



Disinfecting Wharf and Bathhouse, Marivales Quarantine Station, Philippine Islands.

with this disease have been admitted to the Marine Hospital at Savannah for special observation and study. Similarly patients have been admitted to the Wilmington, N. C., Marine Hospital for the study of hookworm infection. Two laboratory officers were detailed with the mine rescue car of the Bureau of Mines to investigate hookworm disease among miners in southern states and lung diseases among Colorado miners, and also to report on the general sanitation and hygiene of mines.



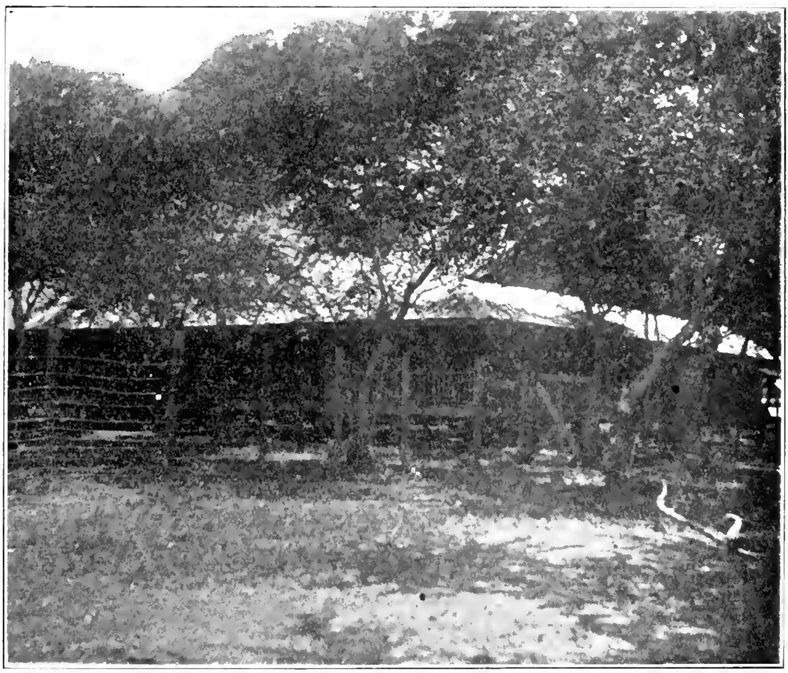
SERVICE QUARTERS, MARIVALES QUARANTINE, PHILIPPINE ISLANDS.

The San Francisco plague laboratory has continued its work of examining rodents for the germs of bubonic plague. It has also made studies on the penetrating power of various gases used in disinfecting ships, on rat leprosy and on the rôle of fleas in transmitting the plague. At the Leprosy Investigation Station in Hawaii, the bacillus of leprosy has been successfully grown on artificial media. Monkeys have been inoculated with leprosy from human beings, and thus the way has been opened for the development of a curative or preventive serum. Special studies have also been made by service officers on such subjects as the sanitary disposal of night soil; the growth of animal tissues outside the body; the rôle of oysters in the propagation of typhoid fever; the longevity of the typhoid bacillus on vegetables; and the influence of poisonous gases on health.

During the summer of 1912, plague broke out in Porto Rico and Passed Assistant R. H. Creel was detailed to direct the work of control

and eradication. In all five officers were engaged in the duty and the outbreak was limited to a small section. As at San Francisco, special emphasis was placed on rat eradication and the rat-proofing of buildings and docks. A general clean-up and enforcement of sanitary measures have been instituted. What might have been a situation full of deadly peril for this country was averted by the prompt and effective work of the service.

The report of the Secretary of the Treasury for the fiscal year of 1911 presents an optimistic picture of the operations of the Public Health Service and recommends certain features which should be further encouraged. Attention is called to the necessity of enlarging



ISOLATION HOSPITAL, CEBU QUARANTINE, PHILIPPINE ISLANDS.

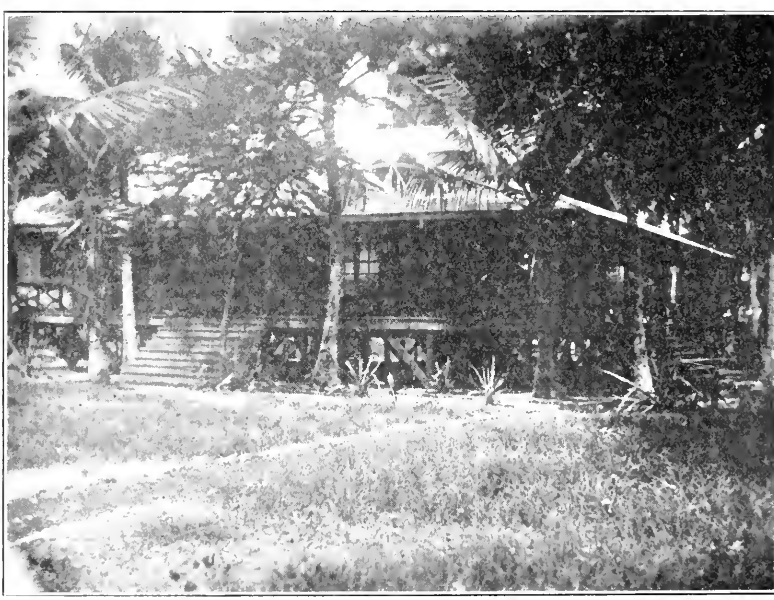
the available fund for fighting epidemic disease. There should be ample provision for emergency measures which may be necessitated at any time by the sudden appearance of epidemic disease, before there is time for Congress to pass special appropriation legislation. Special appropriations are requested for the investigation of pellagra, a disease of serious menace which is spreading widely in the United States, and which threatens to become endemic at terrible cost in lives and money, as it has already done in Italy. Another building is required for the Hygienic Laboratory to provide more room for special researches, disinfection experiments and the housing of small laboratory animals.

The secretary invites particular attention to the "Personnel Bill"

designed to make the pay of Public Health Service officers equal to that of the Army and Navy Medical Corps. This bill was passed by the Senate and reported favorably and unchanged to the House by the Committee on Interstate and Foreign Commerce. Every argument strongly favored its passage. As stated by Mr. Fletcher in the report of the Senate Committee on Public Health and National Quarantine, when the bill was before the Senate:

> In the opinion of the Committee, there exists no such difference in the character of the duties performed and responsibilities assumed, the hazards to which the officers are exposed, or the professional and scientific attainments required in the several services, as to warrant the existing disparity in compensation.

The committee recommended the bill to the Senate, "believing that the maintenance of the present efficiency of the Service, as well as justice to its officers, demands the equalization of pay proposed by the bill." This bill in an amended form, passed congress and was approved by the President on August 14, 1912. It provided for increased salaries, and changed the name from the Public Health and Marine Hospital Service to the more accurate and less cumbersome title, the Public Health Service. The public health functions and duties of the Service were extended. "The Public Health Service may study and investigate the diseases of man and conditions influencing the propagation and spread thereof including sanitation and sewage and the pollution either direct or indirect of the navigable streams and lakes of the United States and it may from time to time issue information in the form of publications for the use of the public."



QUARTERS OF MEDICAL OFFICER, CEBU, PHILIPPINE ISLANDS.

OFFICE OF THE PUBLIC HEALTH SERVICE, KOBE, JAPAN.

On January 13, 1912, the Senate confirmed the President's appointment of Dr. Rupert Blue to succeed the late Dr. Wyman as surgeon-general. Dr. Blue is a comparatively young man, but comes to this responsible post well prepared and with prospects bright for an administration strongly conducive toward maintaining the present high standard of the Public Health Service in personnel and efficiency, and increasing its prestige and value to the nation.

Dr. Blue was born in South Carolina in 1868, graduated from the University of Maryland in 1892, and was commissioned an assistant surgeon in the Marine Hospital Service the following year, after serving an interneship in a Marine Hospital. Four years later he passed the examination for passed assistant surgeon. He attained the rank of surgeon on May 1, 1909. His first eight years in the service were spent in the usual round of routine duties at various points in the United States. In 1903–04 Dr. Blue was detailed as executive officer under Surgeon Joseph H. White, who was in charge of the operations directed toward the eradication of bubonic plague in San Francisco. The following year he assisted in the suppression of yellow fever in New Orleans. At the Jamestown Exposition in 1907 Dr. Blue was made director of sanitation and showed ability above the ordinary in organization and in reconciling the various interests represented at the exposition and making a conspicuous success of its sanitation. He

went from Jamestown to San Francisco, where the plague had reappeared, where he handled the situation admirably, allaying friction and working in noteworthy harmony with the municipal and state officers. Later he spent some time in Europe, studying emigration, preventive medicine and quarantine management. In May, 1910, Dr. Blue was detailed to represent the service at the International Congress on Medicine and Hygiene at Buenos Ayres, and took advantage of the oppor-

Surgeon-General Rupert Blue.

tunities there offered to study possible routes by which yellow fever and plague might be imported into the United States.

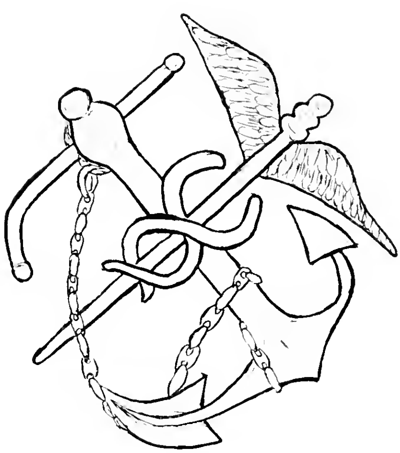
The last detail before he became surgeon-general was in Honolulu, where he was sent to act in an advisory capacity to the Hawaiian board of health and other branches of the territory government in carrying out a sanitary program designed to decrease to the smallest possibility danger of invasion by yellow fever or bubonic plague after the opening of the Panama Canal, and to make their spread impossible, if introduced. The appointment to the surgeon-generalship made necessary the assumption of this work by Passed Assistant Surgeon McCoy, who thus takes up the rôle of adviser to the Civic Sanitation Committee of

Hawaii. This committee is particularly concerned with perfecting sanitary measures to prevent propagation of disease-bearing insects and rodents, and its work is being carried on in conjunction with the territorial board of health.

Dr. Blue has always been especially strong in the field of preventive medicine and quarantine, rather than in the line of hospital service. He is a man of engaging personality, an excellent executive, a skillful organizer and judge of men, and above all, he has in full measure the happy quality of making friends and reconciling opposing interests.

The Public Health Service stands to-day on its record and its aspirations, a monument to the men who have made it, a memorial to the gallant officers whose lives have been laid down in devotion to their duty and the principles of their corps, and the strong bulwark of the American people against the deadly foreign foes of epidemic disease, and the insidious domestic perils of poor sanitation, ignorance and prejudice.

Of more vital though prosaic importance to the nation than either army or navy, it has been less generally known and its work less completely understood. But this is rapidly being changed as the great wave of enlightenment and interest in public and national health affairs sweeps over the country, and as the knowledge is slowly increasing that prevention of disease is the primary and essential work of the physician.



THE INCREASING MORTALITY FROM DEGENERATIVE MALADIES

By E. E. RITTENHOUSE

CONSERVATION COMMISSIONER, THE EQUITABLE LIFE ASSURANCE SOCIETY OF THE UNITED STATES

IT is quite generally believed by those who have studied American morbidity and mortality tendencies that there has been a marked increase in recent years in the death rate from chronic diseases of the important and hardest worked organs of the body. They also believe that this increase is reflected in the upward trend of the general mortality rate in middle life and old age. There are those, however, who assert—obviously without investigation or analysis of the public statistics bearing upon the subject—that neither of these increases has taken place.

And there are still others, some of them prominent in the health movement, who express the opinion—also apparently without reference to the records—that the increase is natural and to be expected. Their theory is that the increase, whatever it may be, is due to the saving of lives in the younger ages, chiefly from communicable disease; that these lives passing into the older periods—many of them with weakened power of resistance—have given us more old people to die than we formerly had.

Such an increase in the number *living* in the later ages would merely lead to a correspondingly increased *number of deaths*, and not to an increase in the *death rate* at these ages, which is the ratio between the number dying and the number living.

The areas where the most dependable vital statistics are to be had, show but a trifling increase in the group above age 40 in each 1,000 of the population, while the death rate in the same group shows a very marked increase.

While the mortality experts of a number of the more important life insurance companies have recognized the increasing mortality in the older ages, and in some instances increased the severity of medical examinations, and in others increased premiums at those ages, only one of the larger companies and one of the smaller ones have given especial attention to the excessive life waste in these ages in their health conservation work.

Mortality Statistics

Much progress has been made in recent years in popularizing our vital statistics, but still much valuable information which should be

placed before the public in concise and popular form lies buried in our official records and in the files of our statisticians and scientists who have analyzed them for their own or scientific use.

Owing to the incompleteness of mortality statistics, especially in former years, it is frequently necessary in making comparisons to insert personal estimates to fill gaps. The rates in such instances are, therefore, deduced partly from statistics and partly from personal judgment.

The statistics used in arriving at the comparisons given below were, however, sufficiently complete to render unnecessary the interpolation of estimates to fill omissions, with one unimportant exception.[1] The rates deduced are the direct product of existing official reports, which are accessible to any one desiring to look them up.

The purpose of submitting these ratios is not primarily to fix a specific rate of increase, but to indicate the *trend* of mortality in middle life and old age in the area named. Those interested in the subject will judge the measure of the actual increase by the value they may place upon the original data from which these rates are extracted.

Degenerative Diseases

That the ratio of deaths from the more important degenerative affections has increased sharply in recent years is so generally known that it is needless to present in this brief paper the indicated advance

Degenerative Diseases

Massachusetts 1880–1909.[3] *Increase in the Death Rate (per 10,000 Population) by Age Periods*

Ages	1880	1909	Increase	Per Cent of Same
All	23.21	43.26	20.05	86.38
Under 5	7.92	10.36	2.44	30.8
5– 9	2.91	3.95	1.04	35.7
10–14	2.85	4.72	1.87	65.6
15–19	3.10	5.43	2.33	75.2
20–29	4.95	8.09	3.14	63.4
30–39	10.13	18.79	8.66	85.5
40–49	19.70	37.84	18.14	92.1
50–59	39.01	91.30	52.29	134
60–69	102.05	212.93	110.88	108.7
70 and over	261.1	558.2	297.1	113

in the rate for each disease separately. They are, therefore, grouped by age divisions. By this method the disturbing effect on the rates of

[1] In the absence of the official figures of the age divisions of the population for 1910, the *ratios* of distribution of 1900 were used. Inasmuch as the change in the percentage of living at the different age periods is very slight in one decade, the actual ratios for 1910 will make no appreciable change in the mortality rates here given.

[3] Massachusetts State Registration Reports.

any changes in classification or improvement in diagnosis is largely overcome. The most reliable records available for this purpose, giving age divisions in 1880, are those of Massachusetts. While the death rates in childhood and early adult life are relatively small, they too show a significant increase.

Included in this group are apoplexy, paralysis and diseases of the heart, circulatory system, kidneys and liver.[2]

The most important of the other diseases of middle life and old age that has increased is cancer. Comparing 1910 with 1880, the cancer death rate has increased in Massachusetts 66 per cent.; since 1900 it has increased 31 per cent. External cancer alone has increased in the entire registration area 55 per cent. since 1900.[4]

In 16 cities the mortality rate from organic heart, apoplexy and kidney affections alone has increased in 30 years from 17.94 to 34.78, or 94 per cent.; during 10 years (1900–1910) it increased from 29.4 to 34.78, or 18 per cent. In New Jersey, 1880–1910, it increased from 16.5 to 34.3, or 108 per cent.

The curves vary in different states and cities, but the same general trend is observed wherever statistics relating to these causes of death are available.

General Death Rate—Older Age Groups

In 1880 the comparisons are confined to Massachusetts and New Jersey, and to 16 registration cities, because in these areas we have the most reliable statistics[5] of that time, from which these comparisons can be carried through to 1910. Both of these were normal mortality years,[6] and, it is believed, represent a fair average of the preceding five-year periods.

That this upward tendency has continued is indicated by a comparison of ten registration states[8] 1900–1910. Increases: ages 45–49,

[2] The estimated deaths in 1910 from these diseases in the United States (based upon the Reg. area) were 367,700.

[4] U. S. Mortality Statistics, 1900, Census Bulletin 109, 1910.

[5] "The state and municipal registration records were copied and are used in the tabulations instead of the enumerators' schedules. These state and municipal registration records are based on a system of burial permits, and are therefore, probably very nearly accurate. This fact should be borne in mind in comparing the reported mortality of these with that of other localities." (U. S. Census Report, 1880.)

[6] "The census year 1879–80 was probably a fair average year as regards mortality. No great epidemic occurred during this period, unless we may consider a marked prevalence of diphtheria as such." (U. S. Census Report, 1880.)

[8] Registration states in 1900 were: Massachusetts, New Jersey, Connecticut, Maine, Michigan, New York, New Hampshire, Rhode Island, Vermont, District of Columbia and Indiana. Indiana is omitted in comparisons owing to lack of uniformity in age distribution records.

SIXTEEN[7] REGISTRATION CITIES. 1880–1910

Decrease and Increase in General Death Rate (per 1,000 Population) by Age Periods

Ages	D.R. 1880	D.R. 1910	Dec. and Inc. in Rate	Per Cent. of Same
All	22.09	16.36	— 5.73	—26
Under 35	21.4	11.36	—10.04	—47
35–44	13.6	12.29	— 1.31	— 9.6
45–54	18.3	22.07	+ 3.77	+20.6
55–64	29.3	37.54	+ 8.24	+28.1
65 and over and unknown	80.3	89.30	+ 9	+11.2
Above 45	32	40.10	+ 8.10	+25.31
Above 55	48.44	58.82	+10.38	+21.43

.61, or 4.5 per cent.; ages 50–54, 1.16, or 6.7 per cent.; ages 55–59 (decrease), .13, or .5 per cent.; ages 60–64 (increase), 1.48, or 4.6 per cent.; ages 65–69, 3.23, or 6.75 per cent.; ages 70–74, 3.45, or 4.9 per cent.; age 75 and over, .82, or .6 per cent.

MASSACHUSETTS AND NEW JERSEY. 1880–1910

Decrease and Increase in General Death Rate (per 1,000 Population) by Age Periods

Ages	D.R. 1880	D.R. 1910	Dec. and Inc. in Rate	Per Cent. of Same
All	17.63	15.80	— 1.83	—10.38
Under 30	16.3	11.3	— 5.0	—30.6
30–34	9.12	6.99	— 2.13	—23.3
35–39	10.1	8.90	— 1.20	—11.8
40–44	10.20	10.95	+ .75	+ 7.35
45–49	12.20	13.79	+ 1.59	+13.0
50–54	13.70	18.35	+ 4.65	+33.9
55–59	20.49	24.28	+ 3.79	+18.5
60–64	25.69	34.85	+ 9.16	+35.6
65–69	40.5	53.16	+12.66	+31.2
70–74	55.4	75.96	+20.56	+37.1
75 and over	123.68	143.66	+19.98	+16.1
Above 40	25.10	30.42	+ 5.32	+21.20
Above 50	35.24	44.07	+ 8.83	+25.06
Above 60	53.81	67.73	+13.92	+25.87

To summarize, the public records under consideration indicate that:

1. The mortality rate from apoplexy, paralysis, diseases of the heart, circulatory system, kidneys and liver has heavily increased in the younger as well as in the older groups. The total deaths were 367,700 in 1910.

2. In Massachusetts the death rate from these causes has increased 86.4 per cent. in 30 years.

3. In 16 important cities the death rate from organic diseases of the

[7] Sixteen cities: New York, Chicago, Philadelphia, Brooklyn, St. Louis, Baltimore, San Francisco, Cincinnati, Cleveland, New Orleans, Pittsburgh, Washington, Milwaukee, Louisville, Providence, Indianapolis.

heart, and from apoplexy, Bright's and nephritis has alone increased 94 per cent. in 30 years.

4. In Massachusetts the death rate from cancer has increased 66 per cent. in 30 years, and 31 per cent. during the past 10 years.

5. In the entire registration area the death rate from external cancer alone has increased 55 per cent. in 10 years, from 1900 to 1910.

6. The increase in mortality from diseases of middle life and old age is reflected in the general death rate by an increase commencing in Massachusetts and New Jersey in age group 40–44; in 16 cities group 45–54.

7. The death rate of the total population age 40 and over has increased, 1910 over 1880:

In Massachusetts and New Jersey, 30 years	5.3, or 21.2 per cent.
In sixteen cities, 30 years	8.1, or 25.3 per cent.
In ten states, 10 years (1900–10)	.89, or 3 per cent.

The increase in the proportion of older lives in our population has been very slight and could not account for the increase in the death rate.

To what extent are these adverse mortality tendencies reflected in our *total* population? In estimating the probable increase in the entire country, many factors must be considered, the discussion of which would consume many pages.

The rate of increase in Massachusetts and New Jersey (21 per cent.) doubtless approximates that of all of the populous states of the east. This rate would, however, be reduced if merged with the rate of increase for the agricultural population of the western and northwestern states. On the other hand, this reduction would be largely, if not totally, neutralized by the heavy urban and rural mortality in the south.

It would seem an entirely reasonable conclusion that while the average length of life has advanced, the *extreme span* of life has not done so—in fact, the indications are that it has been shortened.

Our failure to adapt ourselves to the extraordinary changes and strains of modern existence is commonly accepted as the cause for this excessive mortality in the later age periods. Even though the statistics indicated no increase, the urgent need for correcting our living habits would still exist.

We may agree that in the long run the trend of humanity is ever upward, and that this is but a temporary reaction, but can we afford to rest wholly upon the hope that race deterioration will automatically cease when our people have had time to adjust themselves to modern conditions? Wise men doubt it. This problem will not solve itself; this adverse tendency will be checked only when our people are made to see conditions as they actually exist, and are aroused to the need of correcting them.

THE LIFE INSURANCE COMPANY AS A DYNAMIC IN THE MOVEMENT FOR PHYSICAL WELFARE

By Eugene Lyman Fisk, M.D.

Medical Director, Postal Life Insurance Company, New York

THE average careless liver, although he may be perfectly willing to swallow some "magic" elixir, exhibits uneasiness tinged with suspicion when approached on the subject of prolonging his life by means of adjusting him to his environment. He is more than likely to regard the span of life as fixed by some immutable, if not divine, law, and while comfortably optimistic about attaining the limit fixed by such law, cherishes but little hope of "beating the game." In other words, that convenient individual, the "man on the street," is sceptical about materially prolonging his life without surrendering some of the indulgences which he thinks make life worth living. It is this attitude of mind which leads him frequently to characterize the health-reformer as a "kill-joy," who is "against everything." Now it is unquestionably true that the health-conservation activities that have lately arisen in a few of the leading life-insurance companies have for their business object a mere mathematical increment to the years of life. Indeed, the only legal warrant for the expenditure of the policyholders' money in this work is the probability of attaining such a result, and thereby lowering the cost of insurance. But it is far from the minds of those directing this new force for human betterment, to advocate a mere niggardly or parsimonious hoarding of existence, without regard to its quality, color or meaning. The real warfare is against needless misery, preventable disease, mental and physical inefficiency, and the pitiable handicaps that not only shorten life, but take out of it the color and the satisfaction that make it worth living. Using the term in no sinister Nietzschean sense, the superman should not only live long, but live well, deriving his joy in life from the normal hormones circulating in his tissues, and not from the fleshpots or narcotic indulgences of our friend the careless liver. The prolongation of life is the end that justifies the financial expenditure, but the immediate work in hand is to make life more livable.

Let it be understood, then, that the health-conservationist who is not himself in need of mental hygiene is "against" many things, in favor of many things, and out to kill only the kind of "joy" that kills.

The belief that the death-rate, especially among selected insured lives, is a fixed quantity, is still held by many experienced insurance

men, notwithstanding much recent evidence to the contrary. The constant use of actuarial tables, both in business practise and in the statutes governing the maintenance of reserves by life-insurance companies, tends to give a certain fixity and authority to such tables which they derive from no natural law.

The recent medico-actuarial investigation of the experience of 43 American companies, for example, shows a marked improvement since the quinquennium 1885–1890, among the younger-age groups, and a distinct deterioration among those over age 60.

Any assumption that either the death-rate or the span of life is a fixed quantity necessarily involves the postulate that either the conditions affecting the mortality are unchanging, or that each change is neutralized and balanced by some other change, thus keeping the rate in equilibrium.

As a matter of fact, the general death-rate throughout the civilized world has been falling for several centuries, although there is no evidence that the span of life has increased within recent years, the lowered death-rate resulting largely from the saving of lives in the younger age-groups.

That these movements of mortality are not beyond the control of man is shown by this lowering of the death-rate in the age-groups most affected by the communicable diseases which have recently yielded to the attacks of science. That science can likewise influence the mortality from diseases resulting from faulty living-habits or the mere wear and tear of existence, can not be questioned, and the alleged mysterious fixity of the death-rate or of the span of life should not be held up as a bugaboo to restrain such efforts.

That the mortality in the average life-insurance company is far higher than it need be, and could be lowered, even among good, average insured lives, by improved living-habits, is shown by the experience of the United Kingdom Temperance and General Provident Institution.

This remarkable exhibit shows that in the institution mentioned, two large bodies of lives, almost equal in numbers, and homogeneous except for the use of alcohol, moved alongside of each other for forty-four years, and that one group, the abstainers, at all times exhibited a markedly superior vitality to the other group—the non-abstainers—the total difference in favor of the abstainers during the period covered being 27.4 per cent., although the mortality among the general, or non-abstaining class was only 91 per cent. of that expected according to the British O^{m} Table, representing the experience in 63 British offices. This is not an isolated experience, as recent British and American experiences show an even greater difference in favor of the abstainer.

Now it is fair to assume that if, by educational methods, a company could influence 10 per cent. of its policyholders to lead a careful hy-

gienic existence, the mortality in such a group would be lowered at least to the degree exhibited by the abstainers in the British company above referred to.

Inasmuch as the net premium for an abstainer at age 35, under an average distribution of endowment and whole-life policies, would be \$3.03 per thousand of insurance in force less than for a non-abstainer, we have here a figure representing the actual saving on such lives, the net premium being comparable to the cost of manufacture in trade. Applying this factor to the old-line insurance in force in the United States—about \$18,000,000,000—a saving would result, over and above the cost of carrying on the work, of \$5,000,000 annually. There would also be an annual saving of approximately 10,000 lives. These are the mini-

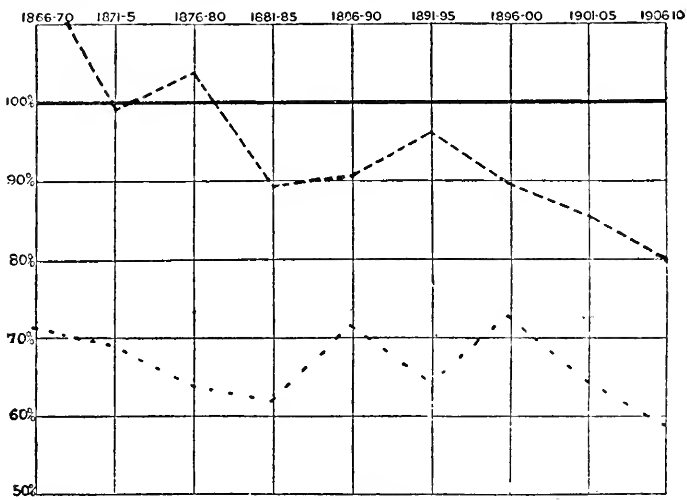


FIG. 1. EXPERIENCE OF THE UNITED KINGDOM TEMPERANCE AND GENERAL PROVIDENT INSTITUTION OF LONDON. Healthy males; whole-life policies; amounts; 1866-1910.
Expected mortality, British O^m table .... ———————— 100.00%
Ratio actual to expected mortality, non-abstainers ...... — — — — — — — 91.27%
Ratio actual to expected mortality, abstainers 66.25%
Mortality among abstainers 27.4 per cent. less than among non-abstainers.

mum figures that can be derived from any scientific ground of experience. They can be increased according to one's confidence in the ability of hygienists to guide the public into conservation methods of living. No effort is here made to compute the enormous reflex benefits to the public at large from these activities among insured lives.

Is the work worth while? If so, how can it be carried on to the best advantage? The answer is found in a brief survey of the resources of the life-insurance companies. 25,000,000 old-line policyholders pay annually, to about 250 companies, more than \$600,000,000 in premiums; these companies hold \$4,000,000,000 in assets to protect \$18,000,0000,000 of insurance in force; they employ 20,000 agents and 80,000 medical examiners, in addition to home-office employees, banks

of deposit and collection, etc., and they pay out more than $400,000,000 annually in death-claims, endowments, etc., to policyholders, all of which is evidence of the vast and intricate ramifications of the business throughout the social structure. Every policyholder is in touch with at least two other individuals, thereby affording the life-insurance companies seventy-five million points of contact with the public, and constantly open channels of communication through which educational material may be transmitted.

We may summarize the reasons why life-insurance companies should engage in health conservation work as follows:

1. The machinery is at hand.

2. It can be utilized without loss, and with probable gain to both company and policyholder.

3. The very nature and extent of the life-insurance business imposes a public obligation to exercise this power for the welfare of the people.

The medical and scientific staff of a life-insurance company is trained in the consideration of disease-tendencies, rather than active diseased conditions. The influence of living-habits and the significance of physical disabilities and abnormalities, and especially of personal and family history, upon large masses of insured lives, form the body of the rapidly developing science of medical selection. By combining this intrinsic knowledge with the readily available extrinsic data relating to personal hygiene, the medical officers of a life-insurance company are, or should be, especially well equipped to guide their policyholders toward safe and sane living-habits. Furthermore, experience shows that the policyholder will listen to the advice of his life-insurance office on such matters, because he discerns the practical business motive that prompts it, however liberal an admixture there may be of normal, genuine interest in human betterment.

The lines along which such work may be carried on are too numerous to permit of minute description in this article. Briefly, they may be summarized as follows: health-hints and instructions distributed with premium-notices; periodical bulletins covering the fundamental principles of healthful living; cooperation with boards of health and other welfare-agencies, by furnishing statistical and other information accumulated by the company's bureau of research; the creation of public sentiment where needed, for the enforcement of health-laws and proper equipment and support of health-departments; persistent effort in favor of legislation for the proper registration of vital statistics; persistent publicity to the need for national, state and local warfare against preventable disease, not only of the communicable class, but of those conditions arising from wear and tear, maladjustment and faulty living-habits. These are a few of the many activities that could readily be carried on by well-equipped life-insurance companies.

The best way to learn this game is to play it. There is such a wealth of opportunity that after the work is once commenced, organization and development will soon follow.

Probably the most important and direct way to benefit the policyholder, and—by force of example—the public at large, is through a system of free, annual, medical examinations, for the purpose of detecting disease or disease-tendencies at the earliest possible moment. This principle of periodic inspection or examination, which seems so radical as applied to man, is accepted as commonplace when applied to the institutions or machines employed by him, such as banks, insurance companies, steam-boilers, elevators, life-preservers, etc., none of which can compare with the human organism in value, complexity or capacity for going wrong. Why not examine the human machine every year? Is there any important objection, except man's silly, subconscious feeling that he is a thing apart from the rest of nature. The *bacillus typhosus* has no such illusions regarding man's apartness, and, however difficult it may be to apply the law of the conservation of energy to man's mental processes, there is no doubt but that it applies to his body, and that the violation of physical and physiological laws is followed by damage and degeneration which are not always manifest until they are beyond the power of science to repair. Many a life has been saved by the warning of incipient disease gained through a life-insurance examination. Why should such benefits be casual instead of systematic?

So much for theory. In a modest way, the company with which I have the honor to be associated has for several years been trying out these theories in the laboratory of practical business experience. Our Health Bureau was established in 1909, and has covered the following activities: periodical bulletins have been issued, dealing with such subjects as the causation of degenerative affections of the heart, blood vessels and kidneys; affections of the nose, throat and lungs, with preventive measures; hygiene of the eye; dental and oral hygiene; obesity and its prevention; drug addiction; physiological effects of alcohol and tobacco; causation and prevention of typhoid, yellow fever, malaria, pneumonia, etc.; increase in the death-rate from cancer, and how to meet it by general and surgical methods; courage as a health-asset; diet-hints; summer and winter hygiene, etc. Statistical pamphlets, addresses, etc., have been issued, showing the increase and decrease in mortality from various diseases, and practical lessons have been drawn therefrom. Many thousands of such monographs have been distributed to boards of health, schools, colleges and other centers of social influence. The privilege of free annual medical examination has been extended to policyholders since 1909. Although less than 10 per cent. of the policyholders have annually availed themselves of this privilege, the results more than justify the company's action. Forty per cent. of the risks examined were found impaired, as some misinterpreted the system as an emerg-

ency relief plan for the sick, rather than a measure of disease prevention. Nevertheless, of those found impaired, 44 per cent. were absolutely unaware of their impairment, showing the positive need for such a system. The following analysis of the impaired lives may prove of interest:

Analysis of Risks Found Impaired
Free Annual Health Bureau Examinations

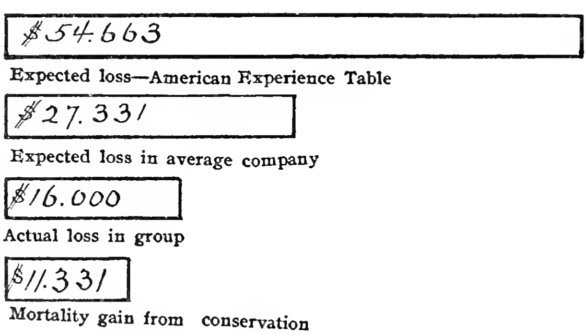
Average age, 49 years, 9 months. Amount of insurance, $1,590,635.

Diseases	Ages 29–30, Per Cent.	Ages 30–40, Per Cent.	Ages 40–50, Per Cent.	Ages 50–60, Per Cent.	Ages 60–70, Per Cent.	Ages 70 Over, Per Cent.	Per Cent. Total Number Examined
Affections of heart, blood vessels and kidneys, diabetes	4.98	13.85	21.65	31.60	23.37	4.54	28
Per cent. at each age-period unaware of such impairment	65.21	57.81	63.00	60.27	56.48	57.14	....
Pulmonary	4.76	35.71	33.33	14.29	11.90	....	2.5
Nervous	6.82	22.72	38.63	22.72	9.09	....	2.7
Digestive	1.66	33.33	25.00	31.66	8.33	....	3.6
Miscellaneous	2.22	17.77	42.22	22.22	13.33	2.22	2.7
Distribution of all impairments by age-periods	4.59	17.91	25.11	29.09	19.60	3.37	39.5

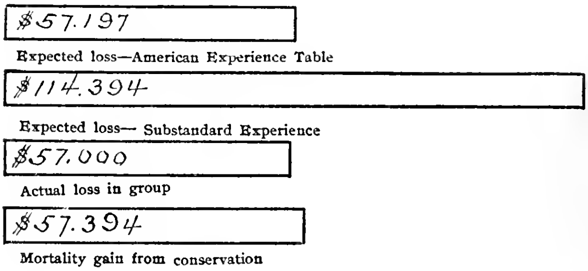
The above should be interpreted as follows: Of the risks showing affections of heart, blood-vessels, kidneys and diabetes, 4.9 per cent. were between 20 and 30, 13.8 per cent. between 30 and 40, etc. 63 per cent. of those between 40 and 50 affected with diseases of heart, blood-vessels, kidneys and with diabetes were unaware of impairment. 4.5 per cent. of all impairments found occurred in the age-group between 20 and 30, 17.9 per cent. between 30 and 40, etc. 96 per cent. of those unaware of impairment exhibited affections of heart, blood-vessels, kidneys and diabetes. 39.5 per cent. of those examined were found impaired.

Attention is called to the large percentage of degenerative affections found at middle life, among those who supposed that they were in sound health.

The mortality experience, although derived from a comparatively small group, has extended over a sufficient period to prove instructive, and is set forth in the following charts:



Group I. No impairment found



Group II. Impaired

Fig. 2. Analysis of Policyholders who Availed Themselves of the Privilege of Free Annual Medical Examination, 1909–1912.

Among those found unimpaired, the mortality was only 29 per cent. of the American Experience Table, showing a saving of about 21 points of the mortality expected by the average company among lives exposed for like periods. These risks, although unimpaired, were advised regarding living-habits, eating, drinking, smoking, etc., and the saving indicated is properly credited to this system.

The group reported impaired comprised some individuals who were almost *in articulo mortis,* hence an expected mortality of 200 per cent. of the American Experience Table might have been regarded as well within the mark. However, the actual mortality in the group was only 99 per cent. of that table. That is, where we expected 200 to die, only 99 deaths actually occurred.

The net saving, over and above the cost of operation of our bureau, was at the rate of about $20,000 per year. Now, the annual saving, based upon the hypothesis derived from the British company's experience would, in our company, have been at the rate of about $12,000 per year, showing that the theoretical estimates were conservative, and more than justified by the actual test of experience. The full effect of the educational propaganda could not, of course, be traced in the mortality fluctuations even of a very large company, and I have only attempted to show the results among those who were actually known to be in touch with our health bureau.

Important health-conservation activities are as yet carried on by only three leading companies out of the 250 now operating in this country. The health bureau established in the Association of Life Insurance Presidents, in 1910, is keeping alive the conservation-idea, but it is a mere adumbration of what could and should be accomplished through the enormous resources available. The pressure of public opinion is needed to set in motion this vast machinery for lifting the burdens of humanity.

NATURAL SELECTION

By Professor T. D. A. COCKERELL
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THE lowest forms of life show the greatest stability in their specific characters. Any one who will examine a little pond water under the microscope will see numerous minute Protozoa belonging to different families, genera and species. Close study brings out the fact that although we regard these as very low types, they are complicated little animals, with remarkable characters. When we look at lists of these creatures, based on collections from different parts of the world, we are astonished to find that most of the species are the same, no matter how remote the localities. When identifications were based merely on comparisons of descriptions and figures, we suspected that the alleged wide distribution of some of these fresh-water Protozoa might be due to mistakes. In recent years, however, protozoologists have frequently traveled, and Dr. Penard, the greatest authority on rhizopods, has been able to determine by study on the spot the identity of Rocky Mountain forms with those of Switzerland. Even more remarkable are the results of Dr. Edmondson, who has visited Tahiti, high altitudes in the Rocky Mountains, and various places in the western central states, with the result of entirely confirming the opinion that most species of fresh-water Protozoa are spread over the world, almost without regard to climate or altitude.[1]

These studies and reports, however, have been based on the species as generally understood. These species are not entirely uniform, but consist of groups of minor races, which also appear to have constant characters and to be of general distribution. Dr. Penard told me that he could greatly increase the list of "species" of rhizopods were he to describe as distinct all the apparently constant forms which he had learned to recognize, and which, so far as he knew, did not conjugate one with the other. He did not describe and name them because their separation required such critical comparisons and familiarity with the subject that very few naturalists would be willing to consider them. Professor Jennings, in his studies of *Paramœcium*, has isolated a number of races or varieties which possess constant characters by which they can be recognized, and which are believed to be common throughout the country.

[1] *University of Colorado Studies*, IX., pp. 65–74; *Science*, September 9, 1910.

Are these Protozoa, then, indifferent to their surroundings? By no means. The experiments of Jennings show that uniformity of environment is not possible even in a watch glass, and that the animals respond readily in many ways to the conditions under which they exist. This fact has tended to obscure the genetic independence of different races, the characters of which overlap, but "pure line" cultures have made it possible to separate them. It has been shown that distinct races may differ only in average characters, a large proportion of the individuals, under ordinary conditions, being indistinguishable by inspection. Such a pair of races would only show absolute differences if subjected to conditions ensuring for every individual the maximum or the minimum growth and efficiency. Such conditions are practically unattainable, and only "pure line" breeding and statistical study will separate the races.

Consequently, in the Protozoa, we have three recognized grades:

1. The species of ordinary taxonomic writings.
2. The minor types recognizable by inspection when the investigator is very expert.
3. The races or strains separable only by breeding combined with statistical study.

Do the third originate frequently without evident cause? Do they then turn into the second, and the second into the first? Jennings did not find it so, but his experiments necessarily occupied a limited time and were concerned with an infinitesimal fraction of the unthinkable myriads of *Paramœcia* in the world. We have, however, the results of nature's large-scale experiment with *Paramœcium*. The genus, notwithstanding its universal distribution and the very diverse conditions under which it must exist, is very poor in species. Either the imagined process does not go on, or it fails before reaching the stage of species-formation, as species are understood by the taxonomists.

In the case of bacteria, and even trypanosomes, it is commonly alleged that environment will change the type. This is constantly asserted by the highest medical authorities, and in a certain pragmatic sense it is of course true. It is found, however, that if the environmental factor is carried too far, or continued too long, the process can not be reversed. It seems nearly certain that the observed phenomena are due to nothing more than a selective process operating on a mixture of races, isolating the one least able to endure. Thus, suppose in a given case we have a culture consisting of one million pathogenic bacteria and ten of an allied non-pathogenic race (presumably there will usually be several grades or races, as with the *Paramœcia*). Apply some treatment favorable to the ten and destructive to the million, and presently the ten are a million and the million reduced to ten or none. The

appearance is that of changing the type by environmental means, but nothing more than selection has been at work.[2]

From all this we are led to conclude that natural selection is continually operative on the lower types of life, the unicellular animals and plants, everywhere affecting the proportions or existence of the races and species. These creatures are *not* adapted to life under all conditions; they are, on the contrary, sensitive to relatively slight changes, many of them probably too slight for us to appreciate. The history of a single culture in the laboratory indicates this. Why, then, are the species so widely distributed, and, on the whole, so constant? Why are they not infinite in number? Why are they not exterminated in great numbers, instead of being of tremendous antiquity, as their wide distribution and the paleontological records show? Where the environment is highly specialized, as in the case of groups parasitic on the higher vertebrata, there is considerable evidence that evolution has to a certain extent kept pace with that of the hosts; yet always tending to lag behind, as Kellogg showed even in the case of the bird-lice, which are of far higher organization than the types now under discussion. In the case of such animals as the fresh-water Protozoa, however, the selective processes have always acted piecemeal, rarely if ever sufficiently widely to destroy a species which had once gained a good footing. They have no doubt destroyed many incipient species, but any tolerably successful type, once widespread, may defy the ordinary processes of nature. In a wide country there is nothing which renders *every* puddle uninhabitable, or *every* part of each pond and river, and survival in a number of places permits the reappearance of the creature in millions when good conditions for reproduction occur. All that is necessary for permanence is an inherent stability of type, which will prevent automatic modification independent of conditions. This stability surely exists in an amazing degree, and may itself be regarded as a product of selection acting through the ages; for automatic instability, manifested too much or too often, would lead to series of changes eventually fatal to existence. A certain looseness of adjustment to surroundings is advantageous, but even slight variations, piled one upon the other, would before long throw the organism out of gear.

Perhaps we may picture the condition of affairs somewhat as follows: There are, let us say, 500 common "situations" in the fresh waters of the world, differing in the temperature and chemical content of the water, in the presence or absence of particular enemies, in the quantity and quality of available food, and I know not what else. These are

[2] There is some evidence, the precise value of which can not at present be determined, pointing to a selective destruction of certain germinal elements under special conditions. This, if adequately confirmed, may equally explain some of the results obtained with trypanosomes, and the often-quoted work of Tower and MacDougal in inducing heritable variations.

not constant for any one body of water for any length of time, owing to seasonal and other changes. An organism adapted equally to any one of the 500, if that were physically possible, could not be *closely* adapted to any, and would be perhaps more or less inefficient under all. An organism adapted exclusively to one or two of the 500 could not in practise confine itself to them, and would be in danger of extermination. There would accordingly arise an optimum condition of adaptability, according to which any given organism would exist under at least 300 of the 500 postulated conditions, would do well under 100, and would flourish exceeedingly well under perhaps 10. Hence the species would be very widespread, would often be common, and would occasionally occur in excessive numbers; which is approximately what we find.

All of this would require in the animals much stability of type. If they varied freely and indiscriminately, the variations being inherited, they would not only tend to lose their standards of efficiency, but the selective processes might make playthings of them, changing them temporarily to meet this or that condition, but rarely able to reverse quickly enough as conditions altered.

The rhizopodous genus *Difflugia* contains a great number of species, differing in the size and shape of the little shells they make. It is not necessary to suppose that *each* species is *specially* adapted to some particular set of conditions, though some of them may be more or less so. It is only necessary to suppose that the difflugian type reached in these animals so many "positions of organic stability," which persisted and survived simply for this reason. There is a "survival of the fittest" in inorganic chemical compounds, following analogous lines.

There is the greatest contrast between these fresh-water protozoans and some of the marine groups, particularly the Radiolaria. Haeckel's great *Challenger* report on the radiolarians only partially indicates the enormous diversity of skeletal structure in these animals. They remind us more of snow crystals than anything else and it is useful to remember here that snow crystals, with all their wonderful diversity, are simply H_2O. It is impossible to believe that all this radiolarian diversity can be adaptive in more than the most general way; we would rather believe that it is possible because of the relative simplicity and uniformity of the conditions of life, which permit infinite diversity in the details of skeletal structure without injury. There is perhaps a high degree of stability in the protoplasmic structure of the radiolaria, and the modifications in the skeletons or shells may not indicate much fundamental diversity. To what extent the described species are permanent and constant is not known.

In multicellular animals, conditions are in many ways different; yet even here we notice a remarkable limitation in the *types* of cellular

structure produced. What multitudes of animals are made out of essentially the same *kinds* of tissues! How limited in number those kinds are! The plants show the same lack of cellular diversity. Evolution has proceeded by means of new arrangements rather than new materials. This cellular stability, well fitting the needs of organisms, must have been fostered by selection. The nerve cell, the striated muscle cell, are astonishingly modified from ameboid ancestors, but the power that could do so much has left us only a few masterpieces. Is this the result of orthogenesis? Did development proceed along these lines, looking neither to the right nor to the left; or did selection oppose impassable barriers? Perhaps both, since orthogenetic trends may themselves be favored by selection.

Passing from tissues to organs and characters, we seem to find much greater, almost infinite, diversity. Recent research has, however, indicated the presence of determiners in the germ-plasm, factors which may be combined in endless ways in inheritance, but are themselves remarkably stable. It seems nearly certain that, so far from constantly presenting heritable variations, they rarely do so. This conclusion is based not merely on the Mendelian phenomena observed by experimenters, but also on the paleontological evidence. There are many groups of species, such as the oysters and the oaks, which have existed since Mesozoic times, producing innumerable species, but so far as we can see, practically all by the shuffling of characters present within the genus all along. Among the Unionidæ, the fresh-water mussels, Ortmann has recently commented on the occurrence of practically identical shell characters in different genera; while land snails afford a number of similar instances. In insects, these phenomena are constantly observed; types of color and marking are nearly the same in Lepidoptera of diverse structure; and in some of the Hymenoptera peculiar characters, such as spines on the cheeks, appear here and there as if at random. In one genus of bees the sexes differ in the character of the tongue, one having that organ pointed, the other having it obtuse; differences hitherto considered to mark families.

We are, therefore, led to see a certain stability amidst all the instability of the multicellular animals; a stability of types of tissue on the one hand, a stability of determiners on the other. Change in the stuff of which living things are made is not a common phenomenon; indeed, we know little or nothing about it. The experiments of Tower and MacDougal, in which heritable variations were apparently produced, can be explained rather on the supposition that certain determiners were destroyed than on the idea that they were altered.

Natural selection, it has often been said, creates nothing. It merely makes use of the variations already present. In Darwin's time, it was not appreciated that so many of the observable variations are due to the

direct effects of the environment, and are not inherited. To-day, we must throw these out and consider heritable variations only. Now we find that these heritable variations mainly (at least) represent no more than a shuffling of the stock-in-trade of the organism, and if any of them involve absolutely new determiners, we do not know it. The matter is complicated by the frequent appearance of new *characters,* which experimental evidence shows to result from new combinations of the old ones. Thus the pink-flowered and yellow-flowered stocks (*Matthiola*) give white and red-cream flowers in the third (second filial) generation, no matter if the two original strains had been bred true and had remained constant from the beginning of time. Here we seem to see something entirely new, but analysis shows that we have no more than new combinations of certain of the grandparental characters.

What will natural selection do with such materials? It can do no more than favor certain characters or combinations of characters and eliminate others. It can not even eliminate the recessives. The result will be the production of a number of distinct types, without necessarily any forward evolution—anything more than a shuffling and sorting of determiners. So far as we can see, this is exactly what has happened in the case of the oak leaves and many mollusc shells.

The modern school of Mendelian experimenters, who have from necessity confined themselves to determining the inheritance of relatively simple characters, have come to think little of natural selection. They have seen how various combinations can arise, greatly altering the appearance of animals and plants, without selection having anything to do in the matter. They have also seen how certain of these modified types, or others like them, may multiply and spread, without being obviously helped or hindered by selective agencies. Where the characters came from, they do not know; but neither do the selectionists. Let it suffice that we have here an apparently mechanical arrangement, which if left to itself will people the earth with diverse animals and plants, a large proportion of which will get along well enough to survive. Possibly this description is unjust in its application to modern experimenters generally, but it at least represents the attitude of some of the more influential and at the same time marks the recognition of a number of real and important facts. I think that while we shall gladly incorporate the facts into our system, we shall in time come to wonder at the limited view of nature implied by the attitude described. It is all too simple and too easy, it does not take into account the real complexities of life or of organization. It reminds us a little of the school of zoogeographers who would bridge the oceans whenever it seems necessary for some animal to cross, or to have crossed. The experimental work itself is revealing this, as day by day new complications arise.

Darwin and Wallace have talked of the accumulation of small variations, of the effects of natural selection on the perpetual minute variations which all species exhibit. Antiselectionists answer that most of these are non-heritable "fluctuating variations," and as for the rest, they are usually not small, nor is the variation "continuous." Moreover, selection soon gets to the end of its rope. So it seems when we are looking at a single pair, or two or three pairs of Mendelian allelomorphs, all active independently of one another. This, however, is not a true picture of living animals, which are bundles of uncounted "factors," acting together in various ways. Any single factor depends for its appearance and form of manifestation on all the others, as Wilson has urged. It is not a thing by itself; it is the result of a complex equation. Sometimes we are getting along well enough with our experiments, when suddenly things go wrong; not because of error in our theory, but because some new factor, which we were not watching, has come in and disturbed the results. Thus, in breeding red sunflowers, we predicted, and got, a dark red homozygous flower. We also got, but did not predict, a homozygous red in which only the basal half of each ray was of that color. The fact is that many of the wild sunflowers carry a factor for marking, which can be seen with difficulty on close inspection, but in the red it comes out strongly. For reasons of this sort we have not only the complications due to the multitude of factors or determiners, but also those caused by their interactions. Inasmuch as they may influence each other strongly or slightly, and in all sorts of different ways, the net result is that in the more complex types of life we have almost infinite possibilities of variation, quite aside from any question of the alteration of the determiners themselves. Add to this the complications due (it appears) to accidents in the maturation process of the germ cells—such an "accident" probably gave rise to the red sunflower—and we have in most cases as much material for natural selection to operate upon as Darwin or Wallace ever postulated. Enough, indeed, to account for all the wonderful adaptations in the tropical fauna and flora, when we consider the time available for their production.

It has recently been announced, as the result of the museum work of Dr. K. Jordan, combined with the field and breeding observations of Dr. G. D. H. Carpenter,[3] that an African butterfly of the genus *Pseudacræa* occurs in a variety of forms, which imitate species of *Planema* flying with it. The extraordinary thing is that one phase of this *Pseudacræa* is sexually dimorphic, imitating a dimorphic *Planema*, while in the same forests it also occurs in two monomorphic forms, resembling two other monomorphic species of *Planema*. Dr. Carpenter succeeded in breeding one of the monomorphic *Pseudacræas* from an

[3] *Entomologists' Record*, XXIV. (1912), p. 233.

egg laid by the other. In a case like this, we have the result of a Mendelian experiment performed by nature. The different phases are represented by interchangeable units, and interbreeding normally occurs. Hence, an extreme case of polymorphism, in which *all* the alternative forms which have been preserved are at present favored in the struggle for existence. Of those which, in the ages past, have disappeared, we have now no trace, but theoretically we should expect some non-mimetic recessive combinations to occur as occasional aberrations. This, I believe, accords with the facts.

Those who examine remarkably adapted forms are always impressed by their striking characters, and find it hard to believe that they have arisen by gradual steps from the more ordinary types. They do not appreciate the ages during which these forms have been evolving, and the multitudes that have perished. Among insects, however, the number of surviving species is usually much greater than in any other group of animals, so that it is possible in a certain sense to compare a specialized type with its ancestors, or at least with contemporaneous species having many of the marks of its ancestors. For this reason insects are exceptionally valuable for the study of evolution; though hardly equal to mammals, which have changed so rapidly within comparatively recent times, and have left us such admirable fossil remains. It would be a useful contribution to the theory of evolution to take up a number of the cases of mimetic or otherwise peculiar insects and show how they are connected by many steps with the more ordinary forms. This has, indeed, been done in part, but it has been difficult, requiring immense and carefully worked out collections. In the Lepidoptera, where these studies are most interesting, the work is being immensely facilitated by the publication of Dr. Seitz's magnificent volumes on the Macrolepidoptera of the world, which place descriptions and good colored figures of all the principal larger Lepidoptera at the service of any one who can afford the very moderate price charged.

We may consider, for example, the "Aristolochia Papilios." These splendid butterflies feed in the larva state on *Aristolochia,* rarely on allied plants. They occur on both sides of the world, and are doubtless, as a group, of great antiquity. They are strong-smelling and apparently distasteful to most predatory animals; the other two groups of *Papilio,* not thus protected, frequently produce species which closely imitate them, so much so that "until quite recently models and mimics have often been regarded as closely allied." The great Indo-Australian series of Aristolochia Papilios shows the largest size and extraordinary sexual dimorphism in the *Ornithoptera* series, usually treated as a distinct genus. The great diversity of the sexes, both in form and color, is extremely impressive in view of what we now know about sex-inheritance. The bright colors are most commonly orange, often green,

while the male of *P. urvilliana,* a Solomon Islands species, is marked with blue. The absence of red is noteworthy,[3] although it is not complete, several of the species having a little red on the anterior edge of the thorax or back of the head, or on the under side of the thorax. In the allied tailed series (including such forms as *P. hector* and *coon*) light red spots are frequently developed on the hind wings. The American (neotropical) Aristolochia Papilios, which are much smaller on the average than the oriental, have the markings and form for the most part much like the orange and black oriental group (*P. darsius* of Ceylon, etc.), but where there is orange on the hind wings of the *darsius* group, it is usually bright red in the neotropical series, though occasionally orange, or orange shaded with red. Most of the American species have well-defined patches on the anterior wings also, but these are green, yellow, white or rarely blue, never red. American Papilios of the *lysithous* group resemble the Aristolochia Papilios of the same region in the most amazing way, and these mimetic butterflies are said to usually imitate the sluggish flight of their models. When we have figures of all these insects and their allies before us, we can see how some of the most peculiar types are connected with quite ordinary ones by intermediates, and how each group works on a certain series of available colors and patterns to reach its results.

[3] *P. hypolitus* Cr. (male) is figured as having red on the abdomen. This is probably a mistake, as the description says dark yellow.

SOME RANDOM THOUGHTS CONCERNING COLLEGE CONDITIONS

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AN ever-increasing proportion of the community seems to be convinced that every youth, male or female, on American soil, has a natural right to collegiate and even to professional education at nominal or no cost. That so many have been deprived of the opportunity to acquire a college degree is one of the saddest of the world's many tragedies; good men and women, having exhausted the joy of conscious usefulness in the ordinary philanthropic operations, find new zest in contriving methods whereby those excluded from college attendance may secure the coveted parchment with a minimum of expense and inconvenience. Their efforts to increase the roll of "American nobility" find ready support on the part of college authorities, who are always prompt to aid any good work which promises to increase the enrollment.

This popular conviction surprises no one who is familiar with the history of American colleges. In the early days of this country, when schools of any kind were few, clergymen were compelled to educate their successors or to have none. Those devoted men extolled the honor of their profession, they cultivated respect for knowledge, they awakened ambition in young men as well as in their parents; and they undertook the labor of instruction when candidates for the ministry presented themselves—many times taking them to their homes and sharing with them their scanty fare. No one imagined that any credit was due for this self-denial and added labor. The work had been, so to say, thrown in; it had cost the teacher nothing; he had parted with nothing material and the teaching had produced nothing tangible; at most, he had utilized only spare hours, which, in any event, belonged to the people who paid him a small stipend. In fact, the parents of the young men thought that the loss sustained by deprivation of their sons' services entitled them to credit equally with the pastor; and they were not far wrong, for the education was to fit the son not to gain a livelihood, not to gain higher social position, but to enter a profession which at that time meant little more than poverty and an opportunity for service. When population became denser, pastors opened academies to increase their incomes, but the shrewd people succeeded in turning this to their advantage; the writer has seen a "call" offered more than a century ago, in which the right to have an "academy" was noted as an

inducement. When these "Latin schools" grew into little colleges, parents and students alike knew that requirements of duty were fulfilled by payment of a small fee; the instructors were mostly clergymen who eked out their incomes by serving neighboring churches. It is said that of the first 110 colleges in this country, 100 were founded with training for the ministry as the prime object. The importance of education received full recognition, but teaching as such was not regarded as a serious matter; it was merely an incidental part of a minister's work. The belief prevailed that if a young man was willing to accept an education some one ought to give it to him.

Until 75 years ago, college teaching in the greater part of this country was controlled by clergymen, members of an ill-paid profession. Even now a large proportion of our college and university presidents are ministers, and there are many in prominent places who maintain that higher education should be under clerical supervision. The tradition continues that teaching like preaching is, or should be, altruistic work and the salaries are graded accordingly. Some time ago the president of a great university blamed this lack of appreciation on the materialistic tendencies of our time, casting all on that convenient beast of burden, commercialism. But this is without reason. Failure to appreciate the work of college professors is merely a survival of the hard materialism of early days, when pioneers struggled against a harsh climate and gained their farms by felling the forest. Genuine appreciation of intellectual work comes only in an age like this; it comes with advancing civilization, when men have been freed from bitter contest with nature, with the physical comfort found only in commercial communities, such as Athens, Babylon or Thebes, in the olden times, or the great commercial centers of modern times. Our business men recognize the power of pure intellect; they pay its possessors almost fabulous salaries; they endow colleges and universities in the hope that intellectual training will enable the coming generation to begin where they have left off and to accomplish greater things. The blame for wretched salaries and constantly increasing overwork can not be laid at their door. The scale was fixed originally by clergymen, the one class against which the vague charge of commercialism can not be laid. If the happy day should ever come when lay members of college boards awake to the sense of their responsibilities and gain personal knowledge of the kind and amount of work done by college professors, the complaint respecting small salaries will be at an end.

Conditions have undergone great change since the days of the "Latin schools." When population was sparse, when little money was in circulation, though the people lived in comfort, the modest college, with few teachers, small fees and narrow curriculum, was necessary if the professions were to be recruited. But those conditions have passed

away finally; commercial intercourse is complete and the small farmer handles more money than did his wealthy predecessor of a century ago. College is sought no longer only by those destined for the "three learned professions"; young men of all aims, and a multitude with no aims, are enrolled in the classes; it has become the thing to own a diploma. The faculty no longer consists of five or six men, each supposed to be familiar with everything in the curriculum but, in all reputable colleges, it is composed of teachers who have spent years in special preparation for the chairs which they occupy—a college professorship is no longer regarded as a haven of rest for men who have failed in some other walk of life; the curriculum has been broadened in all directions and the cost per student has been increased by several hundred per cent.

In spite of the changed conditions, colleges, and to a great extent professional schools, are still regarded as closely allied to charitable institutions. The presidents of starveling academies with a college annex go about the country pleading the cause of their poor self-denying professors; colleges are exempt from all ordinary taxation; they maintain costly fields for semi-professional athletic contests to which admission fees are charged; they are permitted to reserve large parks around their buildings, even though the reservation be to secure an unearned increment. This conception that colleges are charitable institutions does comparatively little injury to the community, but it does far-reaching injury to the staff of instructors in that the salaries are adjusted on the altruistic basis. It is felt that the work is so lofty in aim and so important to the human race that no consideration of pecuniary reward should be permitted to corrupt the worker. Not long ago a western association of college teachers resolved that, in their opinion, the minimum salary for a professor should be at least $1,400. The president of one of the colleges asserted that such a minimum would be absurd; that, if the rule were enforced, a very great proportion of the colleges west from the Mississippi would be driven out of existence. If that should be the result, devout lovers of true education ought to establish at once a chain of prayer meetings to bring about the enforcement of that minimum.

But it is very difficult to believe that young men or young women have an inherent right to receive higher education at another's expense. If one can earn such education, it is his right; if another choose to earn it for him, no one may criticize either giver or receiver. All recognize the parent's duty to give to his child every advantage within his means, even at the cost of great self-denial, for he brought that child into the world without its consent. But the responsibility of others ceases at an early stage in education, far below the requirements for college entrance; it extends no farther than the community's protection demands. A wise community will go beyond the limit of its absolute responsibility

and will afford opportunity to acquire enough knowledge to let the youth rise above mere muscular labor; but even this is still far below the demand, for college or professional education is in no sense essential to the attainment of wealth, of political or social distinction or even of great usefulness. There is no more of real charity in endowing a college than in endowing a great hospital, open to rich and poor alike, at nominal or no cost, on the basis of first come, first served.

For colleges are conducted on that principle, as are some dispensaries which make no investigation respecting needs of applicants, and the "charity" appeals for aid in proportion to the amount of business done. No properly equipped college can subsist on the fees as now arranged; each simply doles out alms to rich and poor alike, presenting them in many cases to men who would scorn a gift in money. Too often, a college in appealing for more endowment is asking wealthy men and women to aid it in giving the college course to the children of other wealthy men and women at a fraction of the cost. The condition is worse in the case of professional schools, in which the fees should always cover the cost; the more so, since there is no pressing need for more lawyers, physicians or even clergymen. In this, there is no criticism of those who endow professorships or free scholarships, provided always that they do so wisely. Scholarships should never be given, they should be earned in competitive examination. A professorship should be endowed so generously as to make the salary attractive to ambitious men who have been accustomed to comfortable surroundings; if the income be so small as to be attractive only to those who have served an apprenticeship in poverty, the gift is injurious. Teaching is not the only function of a college; the professors should be investigators also; the man who does not make original studies becomes a dealer in second-hand knowledge, a mere lesson hearer; whatever his salary may be, it is enough. Up to thirty years ago, a stream of contributions to knowledge flowed from the colleges; a great part of the country's advance, intellectual as well as physical, is directly traceable to that stream. But, during later years, the importance of increased enrollment and the necessity for accommodating the increasing number of students without increasing the expenditure or the fees have overshadowed all else; the efficiency system of the factory is applied, the hours of teaching have increased in many cases to beyond those required in the public schools; so that college men of the present generation have neither time nor energy to do such work as was done by their predecessors. Any unrestricted endowment gift which may be utilized to provide an additional number of low-priced instructors so as to accommodate an increased number of students at cheap rates is destructive.

And here one touches the real disease affecting American colleges. There has been a gradual lowering of the actual, not professed, stand-

ing during the last twenty-five years. Constantly increasing enrollment is, for most college presidents and most college trustees, the only proof of success. Canvassing for pupils is as much part of the college plan in some portions of the country as drumming for customers is in a wholesale business house. Of course, no such vulgar conduct is countenanced by the older institutions, which never send their presidents or special agents on such errands. They utilize students as wandering minstrels, who appear as the blank college or university glee club; they have trained bands of student gladiators to contend in intercollegiate contests and they do not discourage the custom of impressing a great part of the student body as "rooters" for the team. Even the great universities do not think it undignified to advertise the attractions which they offer in college or professional schools. In small colleges, the president often announces his annual or semi-annual canvassing tour as systematically and unblushingly as did the commission salesman of 40 years ago. In larger colleges, the annual tour of the president, during which he makes the round of alumni clubs, is a fixed part of the program. He is not scouring for students, but in his addresses he dwells lovingly on athletic successes, on the pecuniary gains during the year, on the remarkably democratic life of the students; he extols the great advantages offered by his college and urges the alumni to prove their loyalty by spreading the facts broadcast and by giving some money to make matters "more so."

The ingenuity of the canvasser and the exigencies of his concern lead some perilously near to something more than mere inaccuracy of statement. The latest achievement is calculation of the proportion of college men recorded, in "Who's Who." The statistics are correct, but the deductions are imperfect. No note is made of the fact that the plan of the American "Who's Who" leads the editor to select chiefly men whose occupation presupposes college or university work. A search for truth would have led not to "Who's Who" but to biographical catalogues of college alumni. That study might have led to discovery of conditions on which the canvasser would have been more than unwilling to enlarge. Certainly, he would have come to wonder why it is that "Who's Who" is so small a volume, as there are so many thousands in this country who own college diplomas.

The presentation is uncandid, for it is intended to convince young men and women that some magic force insuring success resides in the college course—which is not the fact. The college professor is no alchemist to change dross into fine metal; a gymnasium can not give legs to the man born without them; no more can the college professor give mental power to the one who has it not. Men are born as unequal mentally as physically and not all can gain material advantage from college work, though there are few who can not obtain a diploma somewhere.

The elements of success are innate, their combination is complex; without them a man can not succeed, with or without a college course. A college professor accustomed to study his students can make reasonable forecast of their future by end of the sophomore year, if he know their home surroundings. Mere success in college studies means nothing of itself for the future; one valedictorian disappears at once after graduation while another quickly becomes a power for good or for evil. A fellow with low grades throughout startles professors, whose work he detested, by becoming a great man.

Not every young man should be urged to go to college; entrance may be the first step on the road to hopeless failure. The fact that a man is willing to go to college, even the fact that he is willing to endure hardship to secure an "education," is no reason of itself why he should have the opportunity at another's expense. He may be very earnest, but he may lack capacity, or he may have grown up amid surroundings which have dwarfed or stiffened him so that he can not receive much benefit. Such men or women should not waste their time in college. The writer makes this assertion feelingly, for a long procession of such failures passes before him, as he reviews his forty years of college teaching. Earnestness is no evidence of capacity; willingness to endure very serious inconvenience may be evidence only of willingness to follow lines of least resistance. Four years of self-denial at college may be far preferable to four years of hard work on the farm or in the shop. One may remark, parenthetically, that a vast amount of sympathy is wasted on men who work their way through college as though they were a superior type of the race. No man deserves any special credit for undergoing hardships in order to secure what he believes will yield great returns. The gold-hunters of the Klondyke did that and asked neither praise nor sympathy. The men who struggled to make their way through college and who proved in after life that they made that struggle with clear purpose for the future, ask no consideration and challenge the world to accept them for what they are worth. But our land is full of lawyers working as petty clerks, of physicians without practise, of clergymen whom no one wishes. They are embittered against the unappreciative world, which ignores the struggles they made to secure an "education" and insists on taking them at its own valuation. Had it not been for cheap tuition, college canvassers and boards of aid, a very large proportion of these men would not have gone to college and might have led a comfortable existence in some occupation for which they were fitted.

In all frankness, one must concede that the college of to-day does not fit a man for anything—it does not even train him to do clear thinking for himself. In early days, the curriculum was utilitarian in the severest sense of the term. Latin and Greek were learned as languages

because they were to be used. Those languages were, so to say, the vernacular in divinity schools. The writer's grandfather was accustomed to assign a lesson of twenty or thirty pages for discussion on the next day, and the students were expected to discuss the theology, not the Latin construction. One can not repeat too often or too emphatically that Latin and Greek were the all-important elements of the curriculum because they were to be utilized, just as arithmetic has its place in primary instruction. The incessant chatter, which one hears now, about the intellectual strength gained by study of the classics would have excited derision on all sides in those days. When Latin and Greek lost their utility, American colleges should have seized the opportunity to remodel the curriculum throughout; but the opportunity was neglected and the curriculum became a series of compromises between the old and the new, developing at length into aimless election or narrowing groups, the one encouraging shiftlessness, the other tending to weaken the reasoning power. College officials were roused to indignation several years ago by criticisms offered by two prominent business men; the outbursts in some instances were so violent that one might suppose that these philistines had invaded a holy of holies. But one must be judicial. Much of what those critics said is inaccurate, having been accepted on information and belief; but that which they stated as of their own knowledge was true and is true—and too many of the statements were made as of their own knowledge. Every college professor, whose observations extend beyond the walls of his classroom, knows that the criticisms contain only too much that is true. The aimlessness of broad election and the narrowness of groups are destructive.

The able president of one of the best American colleges is reported to have said:

> A college is an institution where young men and young women study great subjects under broad teachers in a liberty which is not license, and a leisure which is not idleness—with unselfish participation in a common life, and an intense devotion to minor groups within the larger body, and special interests inside the general aim; conscious that they are watched by friendly eyes, too kind to take unfair advantage of their weakness, yet too keen to be deceived.

The concluding phrase, "yet too keen to be deceived," must have been penned by one who has forgotten his student days. It will be read with delight by college graduates and will give new sense of security to undergraduates. This example of admirable English and inspired imagination has been of much service to canvassers for so-called colleges and has received more than favorable comment in several addresses. It has been the theme of many a commencement oration and has given zest to many a baccalaureate sermon. But, as presented by its author, it is defective. If he had said the "ideal college," no exception could be taken to the statement; it would be absolutely correct. But

the reader, acquainted with actual conditions, finds himself commenting involuntarily on some of the expressions. If one read records on sporting pages of the great dailies, he will soon discover that the great subjects are athletics and that the broad teachers are professional coaches, who receive larger remuneration than that of the professors. If he read addresses of college presidents at alumni gatherings and consult the columns of college papers he will find little reason for change of opinion. Nor is he likely to find anything different if he look in other directions, though he may gain enlightenment respecting the minor groups or special interests.

A leading metropolitan daily published once a week two pages of news calculated to bind alumni to their colleges—all reference to athletics being avoided. The communications, many of which carried earmarks of official sanction, were examined during several months. Barely 9 per cent. of the space dealt with the curriculum, increased facilities for study, with the work of professors; aside from the incidental references to such matters, the space was devoted to information respecting glee clubs, society politics, college theatricals, glorification of the democratic spirit among the students, the peculiar advantage of the college over its rivals, with not infrequently a more than casual reference to athletics. In comparatively few instances is anything recorded which would lead a wholly uninformed reader to suspect that college is a place for study—and most of those references are not from colleges but from technical schools. If one consider the important place which these interests occupy in the mind of so-called students, and if he add to them football, baseball, lacrosse, hockey, wrestling, boating, swimming, gymnastics, as well as daily, weekly or monthly publications, he will feel convinced that for a great part of the students none too much time remains to be expended or, as some college boys would say, wasted on study. He will be confirmed in his conviction when he observes that intercollegiate contests are not interrupted by such matters as reviews or approaching examinations. The college course need be little more than leaning against college walls for four years—a simple luxury. The opportunity to acquire knowledge and intellectual training is offered, but students are not compelled to accept it or to leave. A man must be a dullard or an idler indeed who can not gain the passing mark by incidental study and by reasonable attention during recitation hours. Frankly, there is no sense in showing surprise or irritation when business men, demanding 98 per cent. efficiency for promotion, designate college work as a four years course in the science of shirking. The absurdity of the conditions appeals to the professional jester, the "student" has displaced the mother-in-law and the politician.

Some prominent universities have informed the community that the college course is not so important as some good people imagine. A de-

cade or more ago several institutions decided that the fourth year in college is unnecessary and agreed to accept in its place, as counting for the degree, the first year in medicine, law or theology; and now comes the startling announcement that work of similar kind is to be accepted in some cases for the third year also. Fifty years ago, the medical course required two years; now it requires four; but the bachelor degree and that in medicine can still be secured in six years as they could fifty years ago. The writer offers no objection to this, as medical study requires work, but such open confession of the degeneracy of college work was hardly to be expected.

Business men are censured for lack of appreciation because they hesitate to employ college-bred boys,[1] but this is unjust. The college graduate has heard so much about the advantages of an "education" that he expects to find a scramble for his services as soon as he waves a diploma. Without loss of time, he discovers that, in so far as business affairs are concerned, his sojourn within college walls has given him little, it has fitted him for nothing and that it has unfitted him for much. Not long ago, some of the New York dailies had columns of letters complaining bitterly of the miserable pay given to college graduates in business offices. Certainly the pay was small, so very small as to suggest that the complainants would have been employed better in self-examination than in writing letters. There is no reason why a business man should pay more to one incompetent clerk than he does to another. Graduate or non-graduate, that is a matter of indifference; the most efficient man receives most; the graduate must begin where others begin—at the bottom—for, at the outset, all are alike ignorant of business affairs. One must concede that college life does not tend to make business men. The college code of honor would not be tolerated for an hour in a business office; from time immemorial, cheating in examinations has been regarded as justifiable to avoid failure, though cheating to gain honors has always been looked upon as base. In the former case, only the faculty is swindled, but in the latter, injustice would be done to a fellow-student. In a business office a man must do his work thoroughly, no 60 per cent. is a passing mark there. Even the class room atmosphere is not always good. Too many college professors know little of the world outside of their community and the utterances of their favorite newspaper or magazine. They have acquired, subjectively, many and serious convictions respecting the moral condition of the community, chief among these being the inherent corruption of commercial life. The student absorbs the doctrines and goes forth burdened with the responsibility of eliminating the crimes, which he is soon to discover are no more prevalent in business than in professional life, being merely the outgrowth of poor human nature.

[1] This does not refer to graduates of schools of applied science.

The constant endeavor after "broader fields of usefulness" does great all-around injury. The anxiety for a constantly increasing number of students, instead of for high quality of work, compels frequent and wasteful public appearance of presidents and professors, that the college may become known to those who do not read the sporting pages of great dailies. The importance of a college education is a staple for editorials in religious journals. Inventive genius is strained in the effort to discover new methods of doing good. One university boasts of 5,000 correspondence students and another of 4,200; others have reached the status of boasting, but without giving details. It has been announced that, by correspondence, one may easily complete the first two years of the college course. Some prominent universities have admitted that the last two years of the course are unimportant; others are endeavoring to convince the community that college attendance during the first two years is quite unnecessary. If the chief purpose of college attendance be to gain a diploma, one must acknowledge that they are all quite right. Students enrolled in correspondence have not reached the dignity of a place in the catalogue, but they need not feel discouragement; correspondence schools, like the summer schools, can not be ignored, and soon the enrollment in some American universities will rival that of medieval Italian universities.

The example of larger universities has not been lost upon small colleges, for they, too, recognize the great importance of extramural work. The writer has just received the bulletin of a small co-educational college, which includes in its scope a college, an academy, a school of pedagogy, a school of music and a school of art. The college curriculum is divided into the proper number of groups, so that the student may specialize promptly with a view to future work. The professors offer from 15 to 31 hours a week in the first semester of the college, which might be regarded by some as a reasonable requirement in the way of work, especially as it appears to be supplemented by duties in the academy. But this is clearly a mistaken opinion. The institution is "planning to bring college instruction, with college credit, to many who can not enter the college halls." Saturday classes, evening classes, correspondence work are offered. Affiliated instruction is proposed for communities which members of the faculty can not reach; high-school instructors, ministers and others of the locality will be in charge of the classes and college credit will be given. Popular lectures by members of the faculty on lyceum and platform occasions, Memorial day, Sunday-school associations, etc., are available; and the college offers lyceum courses of five entertainments for $100 a course, including two concerts, an entertainment in the way of recitation and singing, and two lectures of popular or semi-popular character. "Write

us your needs." Finally, it is announced in bold type that full college credits will be given and that the fees will be moderate. One must not fail to note that the athletic teams of this college rank high; there are less than seventy male students, of whom 60 per cent. are freshmen and partials. Truly the scope of college work is expanding; dressmaking and folk dancing have attained the rank of university studies and, judging from past occurrences, there is every reason to suppose that they too will find their place along with other studies in literature and pure science among qualifications for the Ph.D. As that degree has now an actual commercial value to the possessor, the college should make its requirements not too severe.

But one can not contemplate this amazing increase in the number of candidates for degrees without apprehension. It was not without reason that a foreign visitor recently spoke of the American as "education-mad." A note of alarm was sounded in France several years ago, because there were 36,000 students in the universities and professional schools; it was thought ominous for the republic's welfare that so great a number of Frenchmen were looking forward to professional life, to abstinence from physical labor: how much greater is the danger here, where colleges claim an attendance nearly ten times as great; the greater proportion of the students are looking forward to teaching or some profession. Kinds of degrees are multiplied to suit the capacity or lack of capacity of the hoped-for students; hundreds of Ph.D.'s are put forth each year with narrow specialized training, most of whom expect to be employed in colleges where they may promulgate their *a priori* doctrines respecting conditions and remedies. Manual labor is despised; the youth of the land are flocking to the cities, which are already overburdened with the class not "fitted for anything in particular"; the trades are passing into control of aliens who exploit the country. They give opportunity to radicals for denunciation of a cold-hearted community which permits them to wallow in wretchedness and in a few years they return to their own land with a competence.

The wide-open door to higher education is not just to the community. Many writers appear to hold that the salvation of this country depends on education of all the people and college canvassers find in this a noble text. But secular education is no panacea for evils, public or private; on the contrary, it may aggravate them. Intellectual training in no wise affects the moral sense. Even in denominational colleges of the strictest type, direct moral instruction must be subordinate and somewhat generalized; and in any event the value of such instruction depends wholly on the standing of the man who gives it. The average professor in our larger colleges is hardly so important as the football or rowing coach, while in small colleges such instruction

is given too often by one whose profession is along that line and the student is apt to think that it is only business, any way. But at best, instruction in morals comes to only too little, as one may see in professional schools. In those, the whole training from the very beginning tends to enforce the doctrine that a keen sense of honor is essential in professional life, yet one finds that in all professions—without any exception whatever—there is too great evidence that training in this respect has done little to overcome the natural tendency of mankind. Unless the surroundings, whence the student has come or amid which he lives, are such as to strengthen the moral tone, the man is likely to gain little in college, while the many special and unavoidable temptations of college life increase the danger of losing much that he already had.

There is need of notable changes in college affairs.

The waste of time in preparation for entrance is prodigal. The requirements for admission to the classical course in New York state when the writer entered college in 1858 were practically the same as now in Latin and Greek; there have been added almost a year of mathematics and, nominally, three years in English. The word nominally is used advisedly. The modern requirements are arranged with great show of importance and consist of study of some examples of fine writing; but they are a wretched substitute for the severe drill in the use of English, which was an important work in all private schools. The average city boy in the 50's, beginning systematic study when eight years old, usually completed preparation for college when he was fifteen and very many times when fourteen; it was believed at that time that the preparatory schools had attained the limit in the way of lengthening the period, and it was recognized that an ordinary boy could complete preparation by the time he was thirteen, without any strain on his health or interference with recreation. The now prevailing anxiety for the health of pupils, the craze for "short lessons well prepared" and the desire for continuing receipt of tuition fees have added unnecessarily three years for preparation. The padding of high and grammar school courses with unessentials to the utter neglect of such essentials as reading, spelling and the proper use of the English language may be justified by the necessity for holding pupils as long as possible to provide opportunity for more teachers of the higher grades, but it is not justified by the product. Boys are not so well trained at eighteen as they were fifty years ago at fourteen. They do not think, they do not know how to think; the modern method seems intended to prevent all necessity for mental exertion and the text-books are as easy as padded crutches. The mental drill which should be given to the youthful pupil has to be given in the freshman class at college. The college authorities should demand less in mass but more

of thoroughness from the preparatory schools; entrance examinations should be to determine how well the boy has been trained, not to ascertain how fully he has been crammed. It may be well enough for colleges to waste their students' time in athletic contests for advertising purposes, but such "commercialism" in preparatory schools should be treated with indignation.

College methods should be changed. But first of all, there should be a definite legal determination as to the meaning of the term "college." The several states should respect themselves and should repeal the charters of many schools which have power to grant degrees. Drastic treatment has been applied to medical schools within the last two years and similar treatment should be applied to academies which masquerade as colleges and count as students all pupils, even those in the primary department. It has been said that the existence of such colleges is justified in many places, for the question is either poor colleges or none. Not at all. There is no reason why these academies should be called colleges and be empowered to grant degrees which the recipients think equal to those obtained from colleges properly equipped with men and materials; they should be recognized only as academies and as such they should be self-supporting. There is so reason why an academy in a prosperous community and with 400 pupils should not be self-supporting. If comfortable farmers are unwilling to pay the cost, that is no reason why overtaxed city dwellers should meet the deficit; the canny agriculturist has overreached the great cities sufficiently through methods of real-estate assessment.

The cost of some so-called "colleges" is appalling. The writer recently received a circular appealing for assistance to save a college whose prosperity threatens its existence. The "institution," in a prosperous agricultural region, has almost 500 pupils, including the summer school, whose utility in swelling the catalogue list has been discovered. Of the grand total only one seventh can be classed as taking college courses and the academy contains scarcely so many. During the year 1911–12 the expenditures were almost $49,000 and the deficit was about $23,000, or an average expenditure of $100 per pupil—while the receipts from tuition fees of all sorts amounted to only about $7,500. Of the money expended, $17,000 was paid to teachers, but the other expenditures show some surprising features, for one finds $4,800 for "other salaries"; $1,000, "other expenses"; $5,600, "printing and advertising"; $1,360 for "travel," making a total of nearly $13,000 for administration and publicity in a prosperous community, which cared so little for the advantages that only $7,500 were paid as fees for almost 500 pupils. During an existence of twenty-nine years this "college" has succeeded in accumulating an alumni roll

of 63. The writer has gathered numerous catalogues and appeals during the last two years and he can present other illustrations of the same type. Whether or not a state should permit multiplication of such colleges may not seem to many to be an open question.

The real colleges and universities should come to an honest recognition of the fact that they were founded to produce mental, not physical athletes; college authorities and they alone are responsible for the common belief that, in college, intellectual work is less important than physical. "Methods of the shop" are denounced by many college presidents and by many professors as degrading; but nowhere are those methods more conspicuous than in colleges themselves. The only evidence of success, apparently, is increased enrollment, more funds, more houses, more low-priced teachers. Quantity, not quality. College presidents and professional canvassers hawk their wares as blatantly as criers at a fair; advertisements are placed in journals and circulars are sent broadcast, extolling the advantages of the institution as shrewdly as though the wares were oriental rugs; students entrusted to college authorities for mental training are utilized for advertising purposes and the college controls the process. Many colleges have a special exhibition day, when prospective students are invited to inspect the concern. Students, once gained, have an inordinate sense of their importance and resent regulation by the faculty as interference with their rights. Strikes among college boys are becoming only too familiar and the plague has found its way into high, even into grammar schools. Discipline is weakened and young Americans at college are growing up in a school of disobedience and evasion.

College trustees must change their methods; they must acquire a new conception of duty and must remember that they are custodians of a great trust for whose honest management they are responsible. The fact that under present conditions there is none to call them to account should make their sense of personal honor more acute. A trustee should endeavor to familiarize himself with the kind and extent of work done by professors, and should not consent to accept only such information as the president may think proper to present. It is little short of scandalous that great universities with thousands of students and vast properties should be controlled by men who are utterly ignorant of the work which is done or which ought to be done. There is no hope for American colleges, unless their affairs can be placed in charge of sympathetic trustees, who will recognize their personal limitations and will concede gladly that not they, but the faculties are the university. Great railroad companies have been wrecked because financiers on the board of directors insisted on managing the road according to their notions through a financier president; other great companies have been rescued from destruction by repentant boards, who confined

themselves to their proper duties and left management of the railroad to those who understand the business.

There must be a return to the proper conception of a college, a place for study, where men and women may be so trained as to be fit to undertake great things. A college should be exactly such a place as described by President Hyde in the address already cited. But that ideal college will remain ideal until the community has been led to recognize that for a third of a century the whole method has been wrong; that the glory of a university does not consist in the beauty of its buildings, the broad expanse of its campus, the extent of its athletic fields or in the marvelous equipment of its gymnasia, but in the character of its professors and in its equipment for legitimate work; that the greatness of a university does not consist in the number of its students, in the number and variety of its schools, but in the quality of the work done and in the character of the schools. The ideal condition will be impossible until those controlling the affairs of colleges have learned that they are not owners, but trustees, and have to come to recognize their responsibility as honest and honorable men; until they have become convinced that it is less important for a president to be making addresses on public affairs than it is for him to attend to college affairs —for which he should be held to strict accountability.

There must be changes in many directions. The mad chase for students should cease, requirements for entrance should be made more severe and students should be accepted, not entreated. Men unfitted by native defect or by environment should be discouraged; the fees should be increased so as to defray the cost; there should be many scholarships, but they should be granted not as gifts but only upon severe examination; they should be earned—the examination should be conducted by a central board of examiners. Intercollegiate contests of all sorts should be abolished; the great stadia should be abandoned or converted to some useful purpose; courses in gymnasia should be compulsory for all students; athletic fields should be opened for use of all and exercise should be encouraged. But every student should know that the aim in all athletic work is to fit him to do better work in the classroom—not, as now, that incidental work in the classroom is required to qualify him for membership on a team. Then, the heroes of a college will not be those who have won their "letters" by muscular prowess, but those who have made high rank in study. It will no longer be a disgrace in "halls of learning" to be a "dig," and one will not be stung by frequent repetition of the assertion that the output of colleges is not equal to that of former days.

HENRI POINCARÉ, the great French mathematician, physicist and philosopher. An appreciation of M. Poincaré was given in the last issue of THE POPULAR SCIENCE MONTHLY. Many of his articles on the foundations of science have been published in recent volumes of this journal.

THE PROGRESS OF SCIENCE

RESEARCH INSTITUTIONS

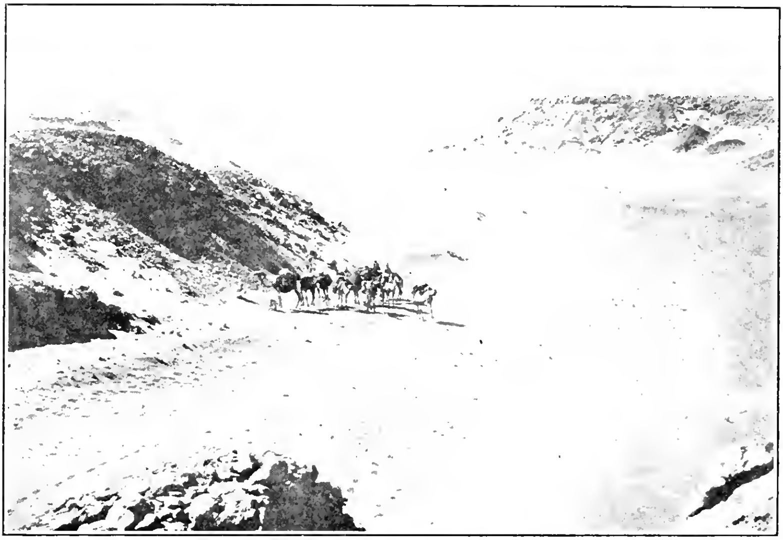
Research institutions are themselves scientific experiments on a large scale, for it is an open question whether research work can be supported to greatest advantage under our universities, by separately endowed institutions or directly by the government. While the answer to this question is important, we can safely assume that scientific and scholarly investigations should be carried forward by all possible agencies, for the returns on the average and in most cases are many fold the cost, both in economic applications and in their contribution to ideal ends. It seems undesirable to urge, as Dean Burgess of Columbia University has done recently, that the establishment of research institutions is unwise and unfair to the universities, or, as is frequently asserted, that the scientific work under the government and in the experiment stations should be confined to the applications of science.

President Woodward, of the Carnegie Institution, is certainly correct when he writes in his last annual report: "The common notion that research demands only a portion of one's leisure from more absorbing duties tends to turn the course of evolution backwards and to land us in the amateurism and the dilettanteism wherein science finds its beginnings." We can not depend, as in the past England has in large measure, on amateurs of independent means to carry on scientific research. Work such as Charles Darwin did at Down and Lord Rayleigh still does at Sterling Place is not attempted in this country. Among our thousand leading scientific men only eleven may be classed as amateurs, and they are not those of the highest distinction. Practically all our scientific men are employed by the universities, in the government service, or by the newly established research institutions.

In the universities the professors are too much occupied with elementary teaching and enmeshed in the machinery of administration. In the government service the experts are too much limited to the application of science and subject to official routine and red-tape. In both cases the salaries paid are smaller than in business concerns, and probably less initiative and freedom are allowed. The scientific man has a more desirable intellectual life; it is truly unfortunate that this should be counterbalanced by irksome restriction.

The research institutions have a great opportunity, and the two to which Mr. Rockefeller and Mr. Carnegie have given their money and their names represent a new era in the development of science. Both the Carnegie Institution of Washington and the Rockefeller Institute for Medical Research have begun well. They can draw their members from university chairs and government bureaus, whereas the reverse movement has not appeared. But it is easier to begin well than to continue in good works. The Johns Hopkins University and the University of Chicago began with new ideals of research and of the professorship, but they have relapsed to nearly the common level. The United States Geological Survey began with a fine spirit, but it can not be said that the value of its work has increased with the multiplication of its appropriation.

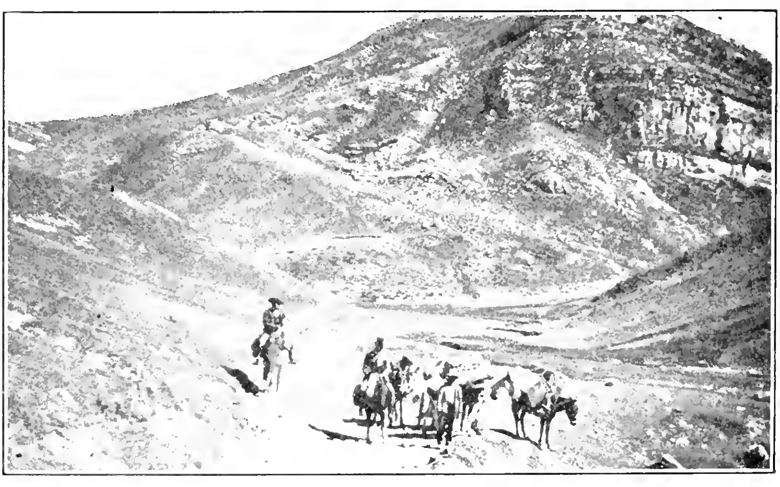
If the research institutions are to do for this country in the twentieth century what the universities accomplished for Germany in the nineteenth century, they must not become bureaucratic machines but must be controlled by their scientific men. They must also be fertile in teaching, no less than in research, as they



Botanical Party Resting in Ascent from Baharia Basin, Libyan Desert.

may well be through the proper use of the 'prentice system. Thirdly, they must keep in touch with the people, so that the work they do will be of benefit to the nation and will be understood to be so.

At the beginning the Rockefeller Institute appears to be fulfilling these conditions better than the Carnegie Institution, perhaps because its problems are somewhat simpler, being confined to a single group of sciences in a definite place, and cultivating a field which is generally recognized as important before all others. It is, however, the case that the Rockefeller Institute has the better organization, being under the control of a board of scientific men and



Magnetic Party *en route* in the Andes, Peru.

giving its members adequate salaries and great freedom and opportunity to prosecute their work.

The Carnegie Institution undertakes to conduct work not only all over this country, but, as is indicated by the illustration, here reproduced from the annual volume, all over the world. With good men at the start, this works well, but one may have misgivings as to the ultimate outcome of widely scattered research work and scientific men directed by a president from an administration building in Washington. The Carnegie Institution would probably have done better either to have established a research university at Washington or else to have used its revenue to endow independent research institutions for special lines of work in different places.

The most desirable institutions for scientific work would probably be comparatively small laboratories conducted by the scientific men who work in them, subject only to some democratic control in case of need. Such laboratories, with small groups of investigators, having similar interests and attracting to them assistants and advanced students, would develop the spirit of cooperation and devotion which is likely to wither under the touch of superior officials and administrative machinery. It would be well if such institutions were endowed by the rich, still better if they were supported by a state or a community.

THE KALLIKAK FAMILY.

IN the training-school for feeble-minded children at Vineland, N. J., is a girl whose ancestry has been traced by Dr. H. H. Goddard and is now published in a small book under the title "The Kallikak Family." The results are of general interest, both as a contribution to our knowledge of the workings of heredity and as a proof of the need of practical measures for eliminating feeble-mindedness and lessening vice and criminality in the community. The feeble-minded girl, Deborah, is a typical moron who may be self-supporting

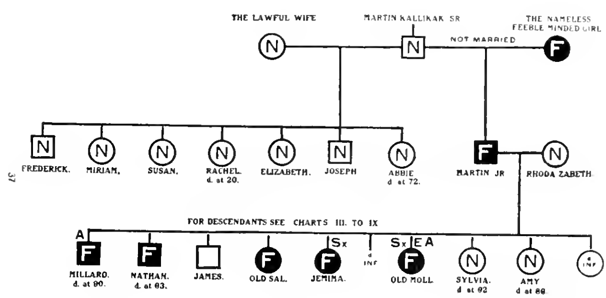


CHART I. THE TWO LINES OF DESCENT FOUNDED BY MARTIN KALLIKAK.

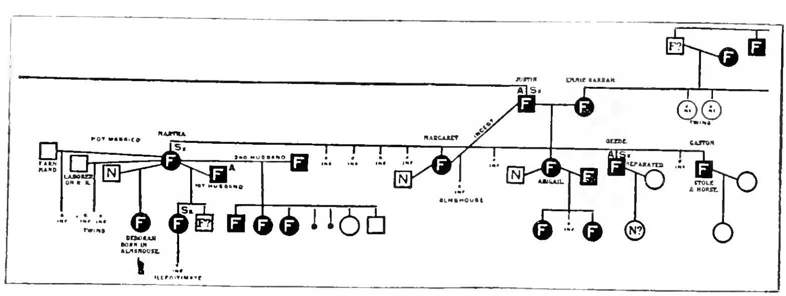


CHART II. THE FAMILY OF DEBORAH'S MATERNAL GRANDPARENTS.

and tolerably useful under restraint, but who would otherwise doubtless continue the family traits of her ancestry.

These are shown on the charts here reproduced. The symbols may seem at first sight to be somewhat complicated, but it is worth while to become acquainted with this kind of terminology. Males are indicated by squares; females by circles. Black squares and circles with a white "F" mean feeble-minded persons; N means normal. When there is no letter the condition is not known. We see on chart II. that Deborah is the illegitimate daughter of a feeble-minded mother, whose father and mother were both feeble-minded and whose sister and two brothers surviving infancy were also feeble-minded. This is in accordance with Mendelian expectation. Deborah had an even chance of being normal; her mother had probably none. In this whole family 41 matings have occurred in which both parents were feeble-minded; they had 222 feeble-minded children with only two who were considered normal. Justin, the feeble-minded and criminal grandfather of Deborah, was one of fifteen children of feeble-minded parents, all but one of whom are said to have been feeble-minded. The father, Millard, was the oldest son shown on chart I., the family consisting of five children known to be feeble-minded and two normal children. The parents of this family consisted of a feeble-minded father and a normal mother. The father was the illegitimate son of a feeble-minded mother and of a man of good New Jersey family to whom the name Martin Kallikak is assigned.

This Martin Kallikak afterwards married and had the additional children shown on chart I. They have had some 500 descendants, all normal, all but three good representative citizens, many of them leaders in the professions and in their communities. The almost equal number of descendants through the illegitimate and feeble-minded son supplied 143 persons known to be feeble-minded and only 46 found to be normal. Among them were 36 illegitimate children, 33 sexually immoral and 24 confirmed drunkards.

A comparison of the two lines of descent from Martin Kallikak certainly exhibits a dramatic contrast, but it is scarcely the natural experiment in true heredity which Dr. Goddard claims it to be. If, on the one hand, Martin Kallikak had left neglected illegitimate children, without taint of feeble-mindedness, it is not likely that they would have established prosperous lines of descent. On the contrary, they would probably have intermarried with the degenerate and feeble-minded. If, on the other hand, the feeble-minded son had been legitimate, he would have been properly cared for, and in all probability would have left no such descendants as came from the illegitimate and neglected child.

SCIENTIFIC ITEMS

We record with regret the death of Dr. John Shaw Billings, director of the New York Public Library, previously surgeon and lieutenant colonel in the army; of Dr. Philip Hanson Hiss, professor of bacteriology in Columbia University; of Mr. John Fritz, the ironmaster of Bethlehem, Pa.; of Dr. Samuel Allen Lattimore, emeritus professor of chemistry at the University of Rochester; of Sir William White, F.R.S., the distinguished British naval architect, and of Dr. G. de Laval, the well-known Swedish engineer and inventor.

THE POPULAR SCIENCE MONTHLY

MAY, 1913

A PROBLEM IN EVOLUTION

BY PROFESSOR WILLIAM PATTEN

DARTMOUTH COLLEGE

I. THE SCOPE OF MORPHOLOGY

WHEN evolution became the accepted doctrine of the natural sciences, it was incumbent on the zoologists to construct a genealogy, or phylogeny, of the animal kingdom, one that would reveal the great highways of evolution and disclose the historic sequence in the rise of new kinds of animals, from the dawn of life to the present time, from the protozoon to man.

A complete genealogy of the animal kingdom, or even one as nearly complete as the biologist may reasonably hope to produce, would be of great value. It would represent the measure of our evidence that animal evolution had taken place. It would constitute the framework of the entire science of zoology, for at the root of every problem in anatomy, embryology, physiology and paleontology is the question of origin. It would be a moving historic picture of evolution, exhibiting the successive stages of the process and the creative value of the accompanying conditions.

The experimental methods of the laboratory and breeding-pen may measure the pliability of life under the momentary stress of artificial conditions, but only the phylogenetic history of large groups of animals, extending over immeasurably long periods of time, under various environments, can indicate the manner in which evolution actually did take place; whether it was slow or rapid, uniformly progressive or spasmodic, direct or tortuous; whether it drifted with the ebb and flow of circumstance, or opportunely threaded its way through an unyielding, but slowly changing, environment. And the manner in which

evolution has taken place is the only thing that can indicate the creative value of the accompanying conditions; whether or no, or to what extent, evolution has been the product of external conditions, of natural selection, or of the fortuitous shuffling of "hereditary units"; or whether, after giving due credit to these agents, we must go still deeper and look for the primary creative factors in a universal, persistent power of growth, and in an internal, automatic adjustment of part to part and part to the whole, which go their ways in spite of the fluctuating influences of heredity, selection and external environment, moving with an increasing momentum of their own along definite paths toward definite ends that are predetermined solely by the nature of organizable materials.

In my judgment, the answer to these problems must come, if at all, from morphology, treated as the formal expression of the dynamics of organic growth, and from the history of its progress as portrayed by the embryology of the individual and the phylogeny of the race. The answer should tell us whether biology shall serve merely to record the phenomena of life, or whether, within its own sphere, it may reasonably hope to attain in some measure the dignity of prophet and master.

II. Missing Links in the Genealogy of the Animal Kingdom

To the layman, the most serious defect in our phylogenetic record is the absence of a connecting link between man and the apes. To the morphologist, dealing with broader aspects of the problem, it is the absence of a whole series of connecting links between the vertebrates and the invertebrates.

The evolution of the vertebrates has extended over many millions of years, from at least the beginning of the Devonian period to the present moment; but during all that time no change in the general plan of their structure has taken place. The vertebrates form an essentially continuous, united group, for the differences between the most widely separated members, as, for example, a fish and a human being, are differences in degree, not in kind; differences in the details of structure, and in the relative location and size of organs and parts of organs, or in the measure of their functions; none whatever in their serial location, in their fundamental structure, or in their mode of growth. Every important part, for example, of the digestive, excretory and reproductive systems, and of the skull, nose, eye, ear, heart and brain of a fish is readily recognized by the trained anatomist in the corresponding organs of man.

It is this broad uniformity in fundamental structure, varied by a continuous series of transitions in organic details, and the historic record of their progress by paleontology, that is the chief measure of blood relationship and community of descent.

The first vertebrates to make their appearance on the face of the earth were fishes. They are still wonderfully well preserved as fossils in the rocks of the Devonian period; and it is perfectly clear that, when alive, they were practically identical in structure with certain fishes now living. But we have no records of true fishes from an earlier period; from this point downwards into the abyss of time, without warning or apparent reason, the vertebrates drop from the records, although the records themselves remain, and they contain, both after that period and for an immeasurably long time previous to it, a full, even a detailed, account of nearly every known group of invertebrates. Why do the vertebrates disappear at this point? Where did they come from? What kind of invertebrates were their ancestors? How did the anatomical structures peculiar to all vertebrates originate? Heretofore no one has been able to give even an approximately satisfactory answer to these questions. Here indeed is a great gap in the evolution of the animal kingdom. It is not merely one link that is missing; the whole middle section, perhaps two thirds of the entire animal kingdom, is either absent, or, if present, it has not been recognized and properly located. As there is no apparent resemblance between the structural plan of any known invertebrate and that of a vertebrate, there is no way of uniting the higher animals with the lower; no way of deciding what was the great trunk line of evolution.

This is a serious defect in the very foundations of the biological sciences. While it remains we are compelled to admit that, with all our boasted schemes of classification according to genetic relationships, the whole class of vertebrates hangs in mid-air over an unknown and apparently inaccessible abyss; that we are totally ignorant of the great creative period in the evolution of the highest type of animals; that we know nothing of the way in which the fundamental structural features of man arose; that we have no basis for the interpretation of the early stages of his embryonic development; and no clue to the initial significance of a single one of his characteristic organs, such as the mouth, notochord, skeleton, lungs, jaws, appendages, heart, thymus, thyroids, pituitary body, pineal gland, sense organs and brain!

III. The Origin of Vertebrates Abandoned as a Hopeless Problem

During the generation following the appearance of Darwin's "Origin of Species," many attempts were made to bridge this great gap in our knowledge of evolution. The best known theories were defended by the most distinguished zoologists of their time; but they were, after all, mere suggestions, and their authors were compelled to unite the nearest probable extremes by long arrays of purely imaginary animals.

Most of the theories were mutually exclusive; none of them were based on detailed comparisons of several systems of organs; and none of them threw any light on vertebrate anatomy, or afforded even an approximate solution of the real problem.

The vital spark in these theories vanished long ago, but certain basic postulates in them have slowly petrified into the semblance of established facts and have introduced into morphology many false ideas, and a system of nomenclature that implies a knowledge we by no means possess. Many a zoologist, proud of his adherence to sound zoological principles, accepts these familiar terms as evidence that the things so named are really what the names imply, as, for example, the terms dorsal and ventral, right and left, gastrula, archenteron, blastopore and cœlomic pouches. The same subtle transformation of theory into fact is shown by the perpetuation of the view that the notochord is made of endoderm because it arises from the walls of the "archenteron"; and by the one that the primitive streak represents the closed lips of an "Uhrmund."

When real progress along the old lines ceased, the problem came to be regarded as hopeless, largely because it was assumed that the ancestors of the vertebrates were small, soft-bodied animals, unlikely to be preserved as fossils. The "practical" biologist then turned his attention to cytology, experimental evolution and genetics, and the study of morphology and phylogeny became almost as discreditable an occupation, especially in the eyes of the new school of biologists in this country, as the study of metaphysics, or the description of new species.

During this long search for the ancestors of the vertebrates, the arthropods (insects, crustacea and arachnids), the largest and most highly organized class of invertebrates were altogether excluded, with astonishingly aggressive unanimity, from their due consideration. It is difficult to understand this impenetrable state of mind, for it did not appear to be based on any known facts, or upon any positive evidence whatever. It was apparently due to a widespread conviction that the general trend of evolution in the arthropods did not lead toward the vertebrates, that the arthropods themselves were too highly specialized to give rise to a new type, and to the fact that the hue and cry of the annelid theory was leading the chase in another direction.

In view of this situation, it may be readily understood that another attempt to connect the genealogy of the vertebrate stock with that of the invertebrates will now have to contend with a widespread indifference born of repeated failures; with interests already diverted into other channels; and with that first, unreasoning hostility that is the protective attitude of the mind toward any strange idea that threatens to steal away our cherished convictions.

IV. First Clues to a New Solution

As long ago as 1889, while working on the development of the eyes of arthropods, the author discovered that the forebrain of the embryo scorpion is gradually covered by an overgrowing fold of skin that converts the brain into a hollow vesicle. During this process, one or two pairs of eyes are transferred from the outer surface of the head to the blind end of a median tube that projects from the membranous roof of the brain.

The details of the whole process by which the eyes were transferred from the outer surface of the head to the inside of the brain were unique in the invertebrates, and so similar to what takes in the formation of the rudimentary pineal eye of vertebrates, that it clearly pointed to some intimate genetic relation between the two groups.

To test what at first sight appeared to be so improbable, a careful study of the anatomy and development of several types of arachnids was made, and, much to our astonishment, it was found that the brain of the arachnids resembled that of the vertebrates in its general shape, in its subdivision into several regions, in the general nature of the functions performed by these regions, and in the character of their appropriate nerves, ganglia and sense organs; that the arachnids possessed skeletal structures comparable, respectively, with the dermal bones, cranium, gill-bars and notochord of vertebrates; and finally it was seen that the development of the embryo and the formation of the germ layers in the arachnids, not only harmonized with, but illuminated the corresponding conditions in the vertebrates.[1]

It was evident that in their fundamental structure the arachnids resembled the vertebrates more than did any other invertebrates; and they resembled them in so many different ways that it became more and more improbable that all these resemblances could be mere coincidences, or could be reasonably accounted for as duplications of structure due to similar functions, or to environment, or to any conceivable cause other than community of origin. Nevertheless, it was hardly possible that the vertebrates came from modern air-breathing scorpions, or spiders, for the lowest vertebrates undoubtedly came from marine animals.

But the modern land arachnids are descendants of a large group of very ancient marine arachnids, the trilobites and merostomata, or giant sea-scorpions, which flourished in the early Cambrian and Ordovician periods, long before any vertebrates were known to exist. They were also found, although in rapidly diminishing numbers, in the two

[1] For a fuller description of these conditions, too technical to be repeated here, see "The Evolution of the Vertebrates and their Kin," by W. Patten. P. Blakiston & Co., Philadelphia.

following periods, and often in the very same deposits in which the first vertebrates are found. Moreover, during the Silurian and Devonian periods, and living in intimate association with the declining marine arachnids and the earliest vertebrates, there was known to exist a peculiar class of animals called the Ostracoderms. Very little was known about them, for their remains were fragmentary and their meaning doubtful. Some of the species were regarded as vertebrates, others as invertebrates, and some of them showed a superficial resemblance to the sea-scorpions, as had been noticed by the older anatomists (Fig. 2). But after considerable discussion and a thorough reexamination of the available material, mainly by Huxley and Lankester, it was definitely decided that they were fishes, probably a very specialized kind, of no great importance morphologically. They were then forgotten, or at any rate their very existence remained quite unknown to many zoologists.

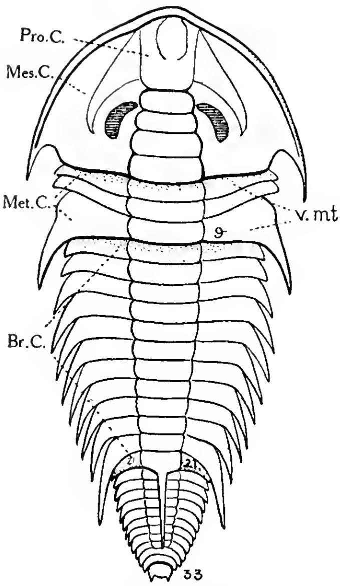


FIG. 1. TRILOBITE (*Mesonacis vermontana* Hall). Lower Cambrian. One of the marine Arachnids.

In view of their unfishlike appearance and their great antiquity, it is astonishing that no one suggested they might be very primitive vertebrates, or perhaps an even more remote ancestral stock, until the author did so in his first paper on "The Origin of Vertebrates."[2]

This oversight was largely due to the fact that, at that time, zoologists firmly believed that the most primitive vertebrates were like sharks, or like *Amphioxus;* that is, animals that had little or no skeleton, while the Ostracoderms were encased in an extraordinary dermal armor, in some respects quite like that of a trilobite or sea-scorpion. Something appeared to be wrong, either in the facts or in the conclusions. Could it be possible that, after all, the ostracoderms were not true fishes, but a new class of animals, a class intermediate between the fishes and the sea-scorpions? In some respects they looked as much like the one as the other, and they appeared at the right time historically to be the long-sought-for missing links between vertebrates and invertebrates. If they really were transition forms, that would fully account for the resemblance between the modern arachnids and

[2] *Q. J. Mic. Sc.*, Vol. 31, 1890.

the vertebrates, for in that case both would be derived from the same stock.

Here then, contrary to all our preconceived ideas, was a new solution of an old and very important problem, probably the most important one before the morphologist since Darwin's time. It was evident that this solution of it, if sustained, would lead to more radical changes in the classification of the animal kingdom than any that have been made since the time of Cuvier and Lamarck. Stated concisely, it was as follows: At some time toward the close of the Cambrian period the sea-scorpions probably gave rise to the ostracoderms, and the latter,

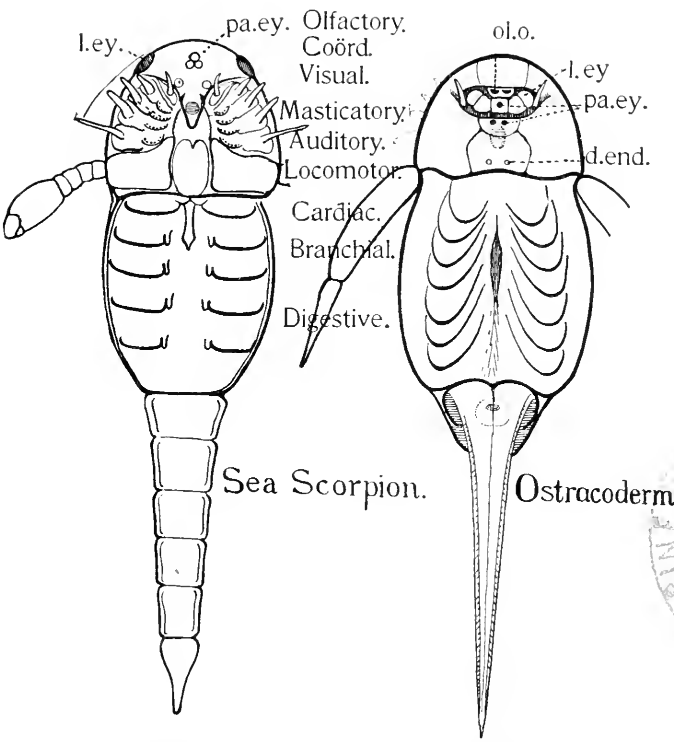


FIG. 2. SEMI-DIAGRAMMATIC FIGURES OF A SEA SCORPION (EURYPTERID) AND AN OSTRACODERM (*Bothriolepis*), showing the sequence in the location of the important functions, and the subdivisions of the body corresponding to the subdivisions of the head and brain in the higher vertebrates.

during the Silurian, to the fishes, or first true vertebrates (Fig. 3). This was an entirely new interpretation in phylogeny, but it was not inherently improbable, or contrary to any established facts; indeed, the first demands of the theory were in full accord with the known facts of anatomy, embryology and paleontology. Let us state it again in this way: In their fundamental structure, living arachnids resemble

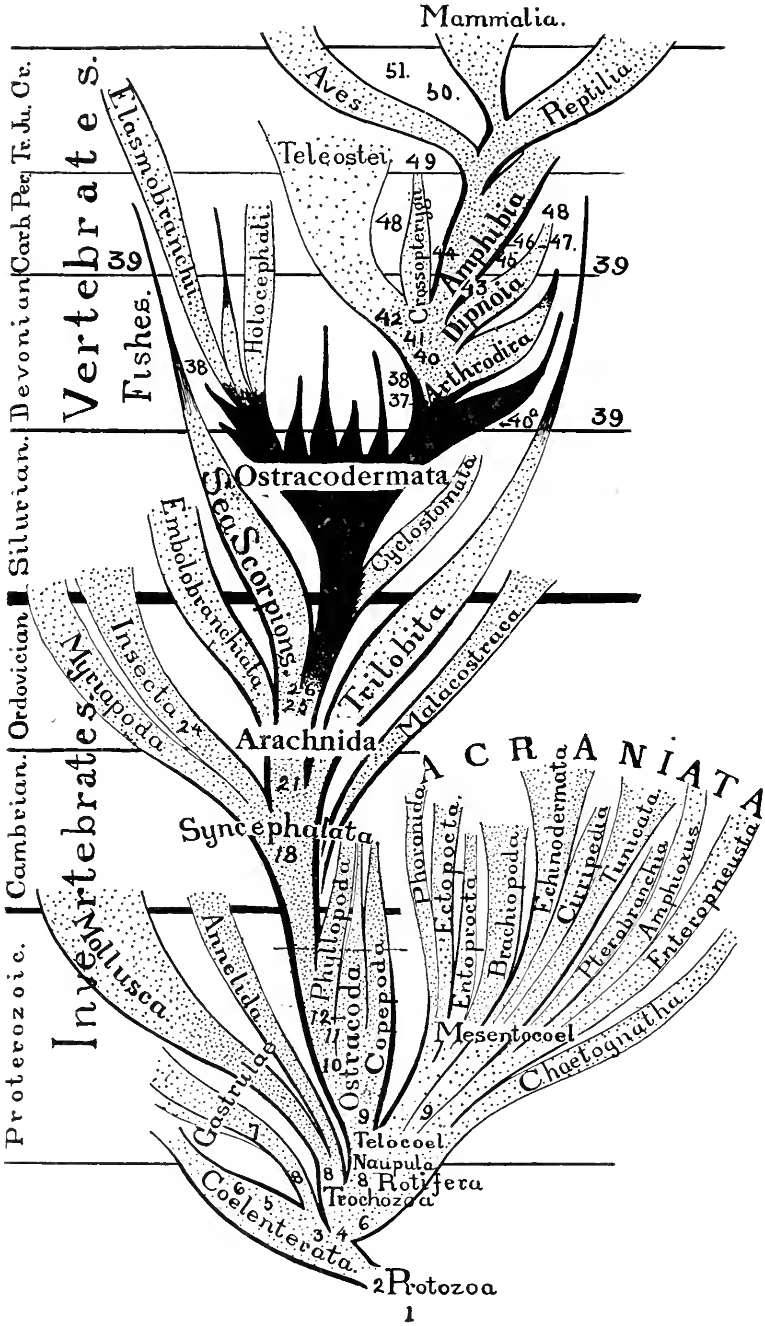


FIG. 3. GENEALOGICAL TREE OF THE ANIMAL KINGDOM, showing the probable genetic relations of the main phyla. The Ostracoderms, the connecting links between the vertebrates and invertebrates, are in solid black.

primitive vertebrates. The ancestral arachnids were marine forms, present in the oldest records we have; they flourished in the Cambrian, and were the highest type of animals in existence at that time. The ostracoderms flourished in the following, or Silurian, period and were the highest type of their time. They had some points in common with their predecessors, the marine arachnids, and also with the true fishes that appeared in the next, or Devonian, period, and which were likewise the highest type of their time. The inference is obvious, that the marine arachnids, the ostracoderms, and the fishes, represent three successive stages in the evolution of the animal kingdom, just as in the later periods the fishes, amphibia and mammals represent successive stages in the evolution of the vertebrates. If this inference is correct, then the whole creative period in the evolution of the vertebrate stock should become an open book, because the materials, both living and fossil, with which one can unravel the evolution of the arachnids, are apparently abundant and accessible.

This situation demanded careful investigation, for the issues at stake were very great. In 1889, when this problem for the first time assumed definite shape in my mind, it was apparently impossible to obtain well-preserved ostracoderms in this country, nor did the known remains in any country appear likely to yield more than the superficial details of their anatomy.

We were thus compelled to wait on opportunity, meantime, during the next ten or eleven years, giving our attention to the anatomy and embryology of living arachnids and the lower vertebrates, convinced that a careful study along these lines would ultimately yield definite evidence, one way or the other. The results fully justified this conclusion, for the longer this problem was studied, the more convincingly did it appear that the differences between these two great divisions of the animal kingdom were largely superficial and could be legitimately explained. The resemblances were fundamental; they were found in unexpected places, in independent systems of organs, and they ran through successive stages in the growth of those organs. It was clear that no other group of invertebrates resembled the vertebrates in such a variety of ways, or to the same extent, as did the arachnids; and no one has claimed that the main facts upon which these resemblances were based are not substantially as I have stated them to be.

We had demonstrated, therefore, that the marine arachnids are to be regarded as the most probable ancestors of the vertebrate stock.

V. The Ostracoderms

But in spite of all that, there still remained a wide gap between the arachnids and the vertebrates, and to bridge that gap we had to find

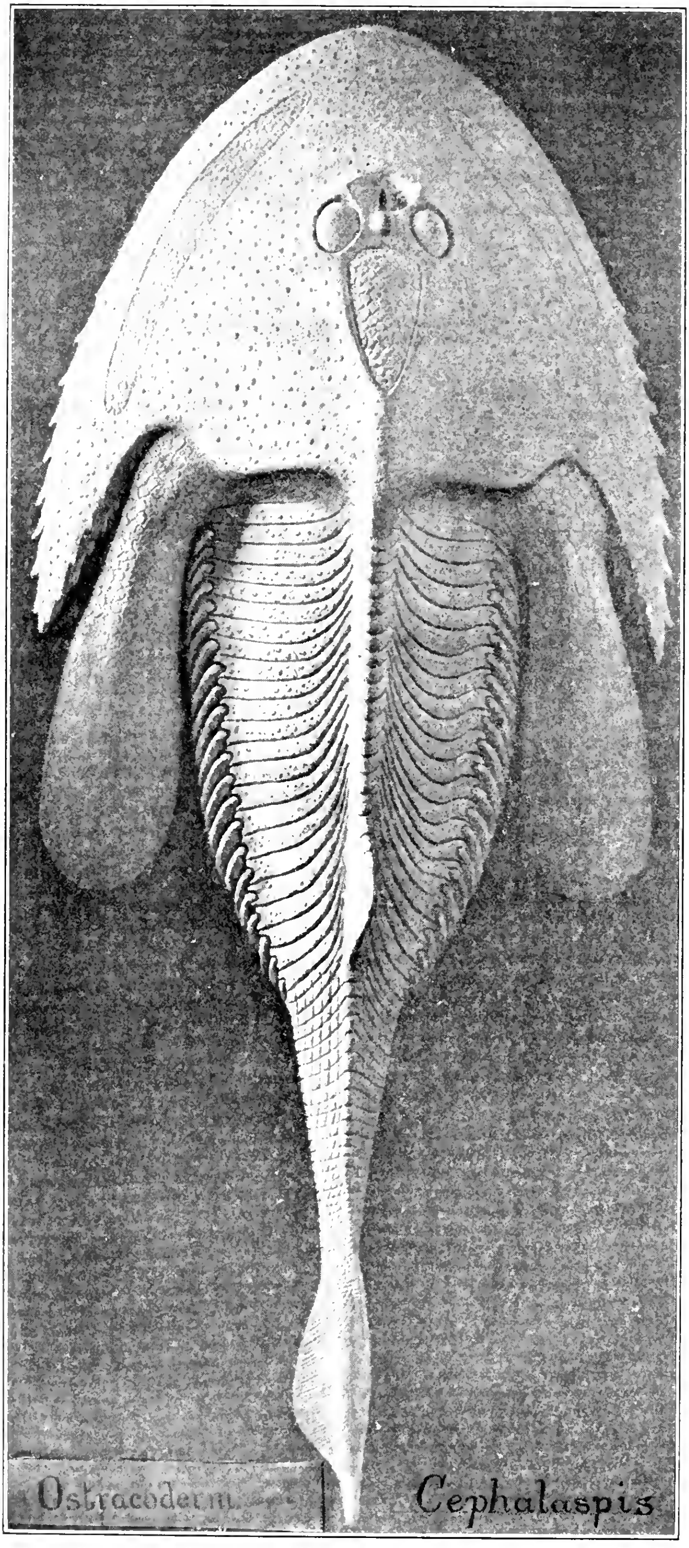


FIG. 4. A RESTORATION OF *Cephalaspis*, based mainly on a species from the lower Old Red Sandstone of Scotland. Ostracoderm.

some animals that were intermediate in structure between them, and which made their appearance at some time not later than the Silurian period. The ostracoderms were the only ones known to science in any way likely to fulfil these requirements; it was, therefore, of the utmost importance to learn something more about these mysterious, extinct animals, for they appeared to contain the solution of the whole problem.

The first opportunity to test this side of the problem came in 1900–01, with a half-year's leave of absence from college duties. The prospects of success, however, were very small, especially for one trained as a laboratory morphologist and embryologist, and without experience in field geology or in paleontology. There was a bare chance that a reexamination from another point of view of the material preserved in the British Museum and other institutions, and that had already been studied by Huxley, Lankester, Traquair, Woodward and others, might reveal some suggestive details overlooked by these past masters of the subject. Failing that, it would be necessary to go into the field and dig up new material that, to serve our purpose, would have to be more perfectly preserved than any that had, by chance, been found in the preceding three quarters of a century. It was not a promising outlook, but the opportunity was gladly accepted.

We first visited the great museums of England and Scotland, and the localities where, in the early thirties, Hugh Miller unearthed the first specimens of these animals known to science, which he afterward described with such remarkable literary skill and enthusiasm in his "Footprints of the Creator," and in the "Old Red Sandstone."

But the best material available in England and Scotland was provokingly incomplete in regard to the very structures it was most important for us to know about. However, some unexpected and suggestive details were found that greatly added to the already keen excitement of the search (Fig. 4).

It was then decided to visit the famous Silurian quarries on the Island of Oesel, in the Baltic Sea, and the museums of St. Petersburg and Moscow, where many of the Oesel fossils were preserved.

The representatives of the ostracoderms (*Tremataspis*) found in the Silurian rocks of the Island of Oesel are only about three inches long. But in spite of their small size, they are, in some respects, admirably preserved in a soft, fine-grained limestone; and they promised to yield important data. In fact, the specimens that were obtained there showed the presence of jointed appendages and shell-covered, stalk-like eyes. These structures were unlike those of true fishes and more like what one would expect to find in some free-swimming sea-scorpion. In that respect the results were highly satisfactory, and added still more evidence in favor of our first supposition (Fig. 5).

But on the whole, we felt that the results of our European expedition were incomplete, because nothing like a full account of the gross anatomy of any one species of ostracoderms was obtained. The organs about the mouth and the location of the principal viscera and of the nervous system were entirely unknown; and it was quite essential to obtain evidence on these points, because it had become increasingly clear that this strange class of animals could not be safely interpreted in terms of either vertebrate or invertebrate anatomy.

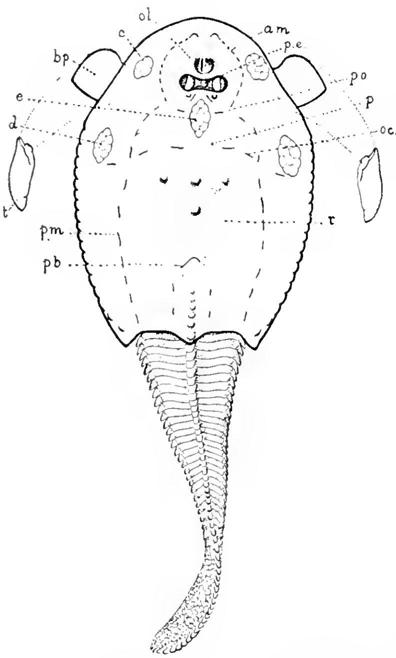


Fig. 5. Restoration of *Trematuspis*, an Ostracoderm from the upper Silurian rocks of the Island of Oesel, Baltic Sea.

On my return to America it was decided to make an attack on a younger branch of the ostracoderms: one that was known to occur in the Devonian rocks of the Bay of Chaleur in Canada.

Four summers were spent in this locality, in search of specimens well enough preserved to be used for anatomical study. Fragments, or in some cases nearly the whole head, could be readily found on the beach at low tide, or by splitting open the disc-shaped nodules that had been washed from the adjacent cliff. But these specimens were generally crushed out of shape, or were so badly weatherbeaten and worn that they were of little value. We hoped to find in the cliff, which extended along the water front for several miles, unweathered specimens that would show not only the whole head, but the rest of the body, the nature of which at that time was entirely unknown. We accordingly examined with great care the face of the cliff as far as it was accessible; and many tons of rock were dug out of it and split open in order to locate the particular beds that contained the fossils; but the latter appeared to be very irregularly distributed, for we did not succeed in finding a single specimen in that way.

At last we found, close to the foot of the cliffs, a large piece of rock that contained several fossils of the kind we were looking for. It could not have been carried there either by the waves or by drifting ice, for evidently it had fallen quite recently from the rocks above. It did not take long to locate, about twenty-five feet above this fragment, the beds

from which it came. To reach them, a path had to be cut into the face of the cliff, and the rocks overlying the beds removed with dynamite, or with pick and bar; an operation not without some danger from rocks that from time to time fell from the crumbling cliffs above. Twice, without warning, fragments weighing some fifty pounds each fell at our feet, knocking the tools from our hands; and where they came from there were other loose ones, at least ten times as large. Our attention was reluctantly, but impartially, divided between the maintenance of a precarious footing on the face of the sweltering cliff, the threatening rocks overhead, and the treasures at our feet.

The bed was not extensive, but it proved to be literally teeming with these extraordinary animals (*Bothriolepis canadensis*), and by good fortune they were in a remarkably complete and instructive state of preservation; more so, perhaps, than any other fossils found heretofore (Fig. 6).

The bed had apparently formed the bottom of a shallow, brackish water-pool in which fern-like water plants had been growing, and where many millions of years ago, with the rise and fall of the tides, these specimens had been trapped, together with other species of ostracoderms and several kinds of true fishes.

The soft mud on the bottom of the pool was now turned into a fine-grained, sandy limestone, and in it the fossilized animals were preserved in the very attitudes they had assumed when they ceased to struggle out of the enclosure. One, in its death agony, had plunged into the mud with sufficient force to remain there, head down, in a vertical position. Others were arranged in horizontal series, uniformly headed in a northeast direction. Their heads were turned against a gentle current of water, as was shown by the fact that the tops of all the ferns were pointed in nearly the opposite direction.

Many of these specimens were so well preserved that the shape of the whole body, and many details on its external surface, could be readily observed; the general character and location of the principal sense organs, jaws, gills, stomach, anus and genital openings ascertained; and the neural and hæmal surfaces identified. It was also possible to determine, beyond reasonable doubt, the mode of locomotion, the mode of feeding and the nature of the food.

Of course this message from a remote past was not off-hand legible. After the scores of specimens were safely housed in the laboratory, it required nearly three years to chisel and scratch and brush away the rocky matrix in which they were imbedded, and after that many specimens had to be cut into serial sections with a diamond saw, and the sections polished and varnished to show the arrangement of the internal organs.

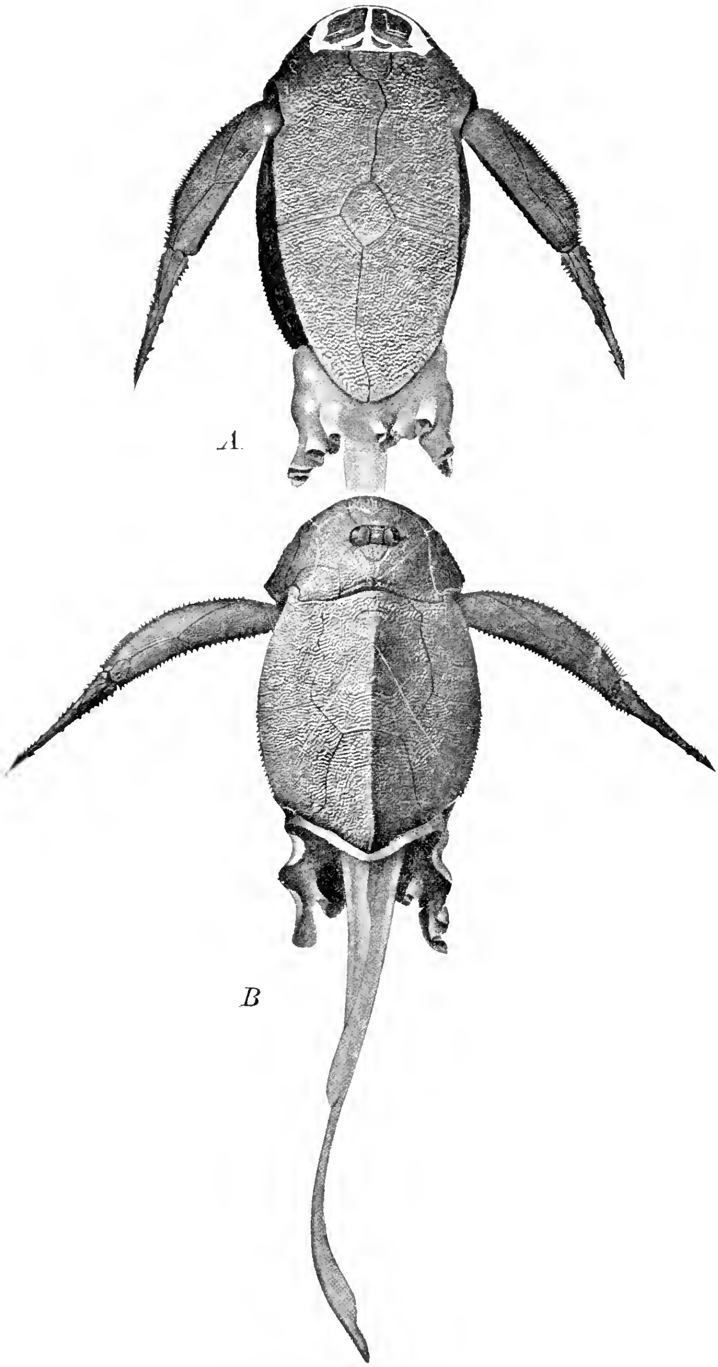


Fig. 6. Restoration of *Bothriolepis Canadensis*; an Ostracoderm from the Upper Devonian of the Bay of Chaleur, Province of Quebec, Canada.

But "the labor we delight in physics pain," and patient labor is but the measure of hoped-for rewards. In this case the realization exceeded all reasonable expectations; for, if he may be counted fortunate who, by chance, finds some soothsaying relic of early life, how much more than fortunate, how exceedingly blest, is the naturalist who is permitted to lift with his own hands from some ancient storehouse of the earth a long-sought-for treasure, and to awake in it, with the chisel's kiss a spirit from the childhood era of the world!

VI. A Critical Period in Organic Evolution

The net result of this fortunate find was to show that the ostracoderms, as had been predicted, were neither vertebrates nor invertebrates, but a class intermediate between the two. They were, in fact, the real missing links in the animal kingdom. The posterior part of the body was membranous and decidedly fish-like in shape; but the contour of the whole animal, especially the head, the nature of the appendages, the eyes and the mode of locomotion, were more like those of the marine scorpions. The gill, or atrial, chamber, and the structure of the dermal skeleton were intermediate in character (Figs. 2 and 6).

But the most important features of all were the long sought for mouth parts, or jaws. They were paired, consisting of four separate jaws, which in chewing, or biting, moved to and from the median line, like the jaws of all known arthropods (Fig. 6, *A*). They were not unpaired arches moving forward and backward, as they do in all true vertebrates.

To realize the significance of this fact, it must be understood that one of the greatest differences between a vertebrate and an arachnid, or arthropod, is the position and character of the jaws and mouth. In all arthropods and arachnids, the mouth and jaws are primarily located on the same side of the body as the nervous system; food enters the alimentary canal by a passage-way in the floor of the brain; and there may be several pairs of jaw-like legs, which, in chewing, work in a lateral direction to and from the median line. In the adult vertebrates the jaws lie on the opposite side of the body from that on which the brain and nerve cord are located; the food that enters the mouth passes directly into the alimentary canal without going through a passage-way in the floor of the brain; and the jaws are two unpaired arches that work against each other in a forward and backward direction (Fig. 7, *A* and *B*).

It is evident that either we are not dealing with the same things in the two classes, or that there has been some change in their relative locations. As a matter of fact, it is part one and part the other; for we have been able to demonstrate: (1) That the nervous system of the

arachnids is identical with that of the vertebrates, and lies on the same side of the body. It affords us the fixed base line of comparison. (2) That in embryo vertebrates there are at least three pairs of primitive jaws that arise from the neural surface; they are gradually shifted from their old position to a new one on the opposite side of the head.

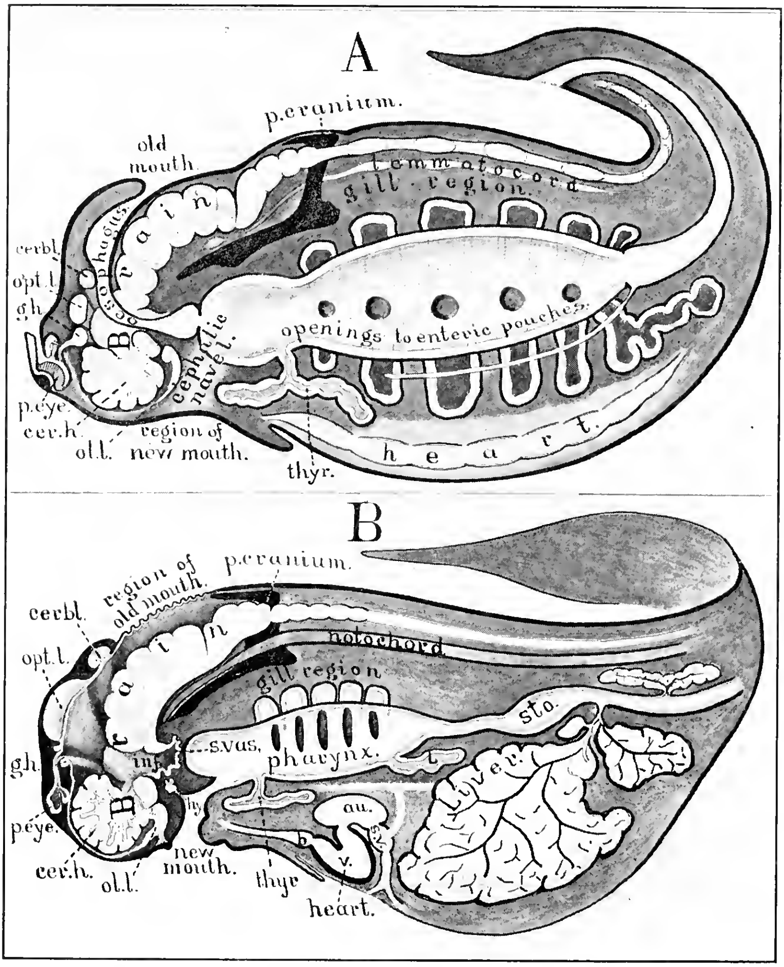


FIG. 7. SEMI-DIAGRAMMATIC MEDIAN SECTIONS OF AN ARACHNID AND A VERTEBRATE, showing the location of the principal organs and their probable relations; *cerbl.*, cerebellum; *cer. h.*, cerebral hemispheres; *g. h.*, ganglion of parietal, or pineal, eye; *hy.*, hypophysis; *inf.*, infundibulum; *ol. l.*, olfactory lobes; *p. eye.*, parietal or pineal eye; *s. vas.*, saccus vasculosus; *thyr.*, thyroid.

(3) That the old mouth and œsophagus of the invertebrates is still present, a useless, heretofore unintelligible, rudiment, in its proper place in the floor of the brain of all vertebrates. This old passageway

is there known as the infundibulum and the saccus vasculosus; it was completely shut off from the outside world by the closing of the brain tube during the process of embryonic growth. (4) The present mouth of the vertebrates is a new one; it arose through the transformation of the so-called "dorsal organ," or cephalic navel, an organ of obscure function, but one that is present in all arthropods near the place where the new mouth of the vertebrates ultimately appears. In the arthropods it may serve as an organ of attachment, and at certain stages of development affords a temporary passageway into the alimentary canal. In other words, the arachnid brain could not continue to grow in volume, and in the particular way in which it had been growing, without closing up the old mouth, and without forcing the jaws farther and farther apart, until they reached the opposite side of the head. Here they converged toward the cephalic navel, which then became a permanent opening and was utilized as a new mouth to take the place of the old one that was being closed up.

Again, in still other words, we are here dealing with a series of interlocking, internal organic adjustments that ultimately reached a condition of unstable equilibrium. A radical and comparatively rapid readjustment then took place, which led to a new condition of great stability. This situation constituted a great crisis in the evolution of this phylum, perhaps the most momentous crisis in the history of organic evolution. But these revolutionary events were brought about in an intelligible way by the cumulative action of long-established methods of growth, which can be traced through the arachnid stock up to the point where the ensuing events appear inevitable. The actual consummation of them marks the transition from the vertebrates to the invertebrates, and the beginning of a new class of animals. From the nature of the case, the transition must have taken place somewhat rapidly, and it probably occurred at some time during, or before, the Silurian period. The paired jaws of the adult ostracoderms are intelligible only on the assumption that they represent one of the early phylogenetic stages of this process.

VII. The Record of Paleozoic Events in Modern Vertebrate Embryos

The general way in which this metamorphosis took place is still recorded in the embryonic history of the vertebrates to the present day, for we can readily observe, in many vertebrate embryos, the shutting up of the old mouth within the brain chamber, the transfer of at least three pairs of jaws to the opposite side of the head, and their union around the new mouth.

In the embryo of the frog, for example, three pairs of rudimentary

jaws may be seen after they have reached the hæmal surface and are assembled around the new mouth (Fig. 8). Ultimately the first two

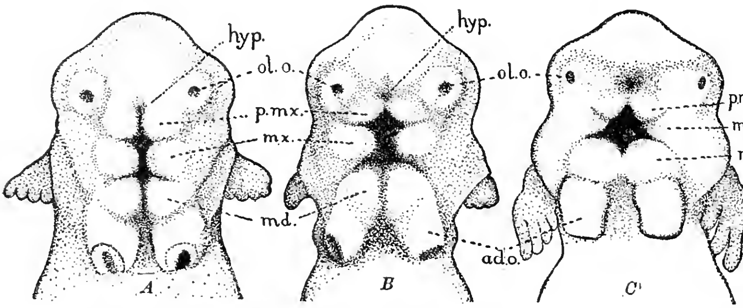


FIG. 8. HEAD OF AN EMBRYO FROG, showing the three pairs of primitive jaws derived from their invertebrate ancestors, and their union to form the unpaired jaws typical of the vertebrates.

pairs fuse to form the fixed upper jaw, and the third pair forms the lower jaw.

The same three pairs of invertebrate jaws are present in the embryonic stages of man. They occupy the same relative positions as in the frog, and their subsequent history is the same (Fig. 9, *A*). Their presence and mode of growth largely control the architecture of the

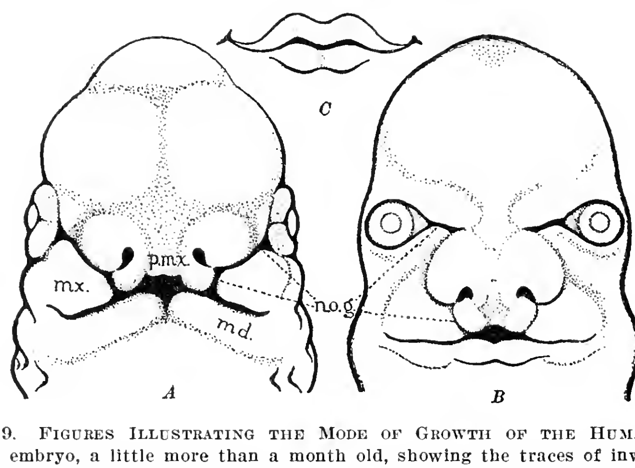


FIG. 9. FIGURES ILLUSTRATING THE MODE OF GROWTH OF THE HUMAN FACE. *A*, human embryo, a little more than a month old, showing the traces of invertebrate jaws in the mandibular, *m. d.*, maxillary, *m. x.*, and premaxillary, *p. mx.*, arches. *B*, embryo a little less than two months old, with the preceding parts nearly united. *C*, mouth of adult, the contours showing its elemental structure.

human face. In rare cases they fail to unite in the normal way, giving rise to such defects in the adult as hare lip, cleft palate and open tear duct (Fig. 9, *B*). Even in otherwise normal faces, the presence of a pronounced "Cupid's bow" mouth, or prominent lateral lobes on the

upper and lower lips, may be regarded as the last outward expression of this primitive condition (Fig. 9, *C*). Thus it appears that the growth of the human face is still dominated by the same forces that have been observed in the remote arachnid ancestors of the vertebrate stock.

There are many other organs of man, especially those in the head, as, for example, the hypophysis cerebri, thymus, thyroid and pineal eye, that have their origin in the arachnids, and it is there that we must look for a better understanding of their significance.

VII. Conclusion

When, in the manner indicated above, we have united the upper and lower sections of the animal kingdom to form one great phylum or highway of evolution, we observe an amazing uniformity and stability in the basic structure and mode of growth of all the animals belonging to it. The direct course of evolution within such a definitely and narrowly circumscribed path, during untold millions of years, and under widely different conditions, clearly indicates, in my judgment, that neither the haphazard shuffling of "hereditary units" in sexual reproduction, nor external environment, nor use and disuse, nor natural selection, has been the chief directing agent in organic evolution. At best, they are of secondary, or subordinate, or intermittent value. The primary and ever present creators of organic structure appear to have been a universal, persistent power of growth, rigidly controlled by the inherent nature of organizable materials; and the internal conditions successively created by growth and organic association.

THE NORTH AMERICAN INDIANS OF THE PLAINS

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ANTHROPOLOGY is one of the newer sciences. Its development during the past ten years makes clear that regardless of the original meaning of the term anthropology, and, in spite of any one's opinion on the subject, it is primarily a culture study. Culture is here used in a technical sense to designate the complex of social and intellectual activities constituting the life of a native tribe or a group of people. One of the most engaging problems of our time is the origin and mode of development of this culture, which is, after all, the distinctly human character that differentiates man from the animals. Modern anthropology has made this its chief problem and has thus set itself over in contrast to biology which concerns itself with man only in so far as he has animal characters. The theory of evolution was devised as a working scheme for the study of animal characters and has therefore little direct bearing upon anthropological problems, notwithstanding the fact that formerly many anthropologists tried to make it their method also. When it became clear to all that the study of man must concern itself with the distinctly human characters, and delegate his distinctly biological problems to biologists, anthropologists began to formulate their cultural conceptions, which is now their working scheme in just the same way that evolution is the method of biologists. Unfortunately, the culture problem appears peculiarly difficult and complex and has, like evolution, become the battle ground for several incompatible theories of origin and growth. Yet, in the course of its labors anthropology has accumulated an unusually large collection of data and has so systematized its results that whole continents may now be divided into culture areas. For some of these areas our information is now so complete that one may form some idea of what went on within their borders in definite periods of time. The anthropological method in such cases is decidedly empirical, for everywhere interpretations are regarded as permissible by historical analysis only.

As an illustration of what has already been accomplished in anthropology, we may attempt a brief résumé of the Plains Indian culture in North America. In North America, as a whole, anthropologists usually recognize from ten to eleven more or less clearly defined culture areas, the approximate borders of which are indicated on the accompanying map. Yet, in most cases these divisions are not absolute, but relative, for rarely can a group of Indians be found anywhere,

however small, that does not show some of the cultural traits of all its immediate neighbors. One of the most striking characteristics of culture distribution is the constant intergradation of traits, so that only in exceptional instances can the cultures of even two neighboring groups be considered exactly alike. Nevertheless, certain groups often possess in common highly characteristic traits, whence they are said to be of the same general types. The divisions on the accompanying map mark off the limits within which the respective sets of characteristic traits seem

CULTURE AREAS IN NORTH AMERICA.

to predominate. Thus, the various tribes of Plains Indians have a number of peculiar traits whose distribution in more or less complete association is taken as indicating the geographical extent of a type of culture.

One of the most conspicuous marks of Plains culture is the relation of the Indian to the buffalo. Though the buffalo, or bison, was at one time widely distributed in the Mississippi Valley, it seems to have been chiefly at home in the treeless areas of the west. After 1800, at least, the large herds were found in the great open stretches of country, east of the Rocky Mountains, or the long narrow white area in our forestry map. While this was the region in which the herds were thickest and typical, there was also a fringe on all sides, but especially to the east, of small random groups of buffalo. We thus see a faunistic distribution making it possible for Indians in the heart of the area to live entirely on the buffalo, while their neighbors could to varying degrees derive partial support from the same source. This is about what observation shows to have been the case.

From the time of exploration to 1860, or later, all the tribes of Indians living within the great treeless area east of the mountains made the hunting of the buffalo their chief occupation. They cultivated nothing and used only a few wild fruits and roots to supplement their almost exclusive meat diet. Reference to the forestry map will show how the wooded area fringes out into the Plains. Now, the Indians living in this fringed area also hunted buffalo, but not exclusively, for they raised maize, beans and squashes. Again, on the west in the open country between the mountain ranges, the tribes occasionally hunted buffalo; but, though they did not practise agriculture, they gathered great quantities of wild grass seeds which when ground and baked formed a considerable part of their diet.

Thus we see that by taking the use of the buffalo as an index of culture we may roughly group the Indians of the Plains under three heads: the typical or primary tribes, the eastern or semi-agricultural tribes and the western or plateau tribes. If we seek further to characterize the culture of the typical group we find the following conspicuous traits: the use of the tipi all the year round; in historic times, the use of the horse; in earlier times the use of the dog for transportation by travois; an organized camp circle and police system for the regulation of the buffalo hunt; a religious ceremony known as the sun dance, and a highly individualized decorative art. Waiving several minor traits, we may take these as determining characters in the typical Plains Indian culture.

On the tribal map we have used an asterisk (*) to distinguish those clearly manifesting these traits. As previously stated, we must not expect every tribe in this group to manifest every typical trait, for here as elsewhere the gradation of culture is in evidence. Further, the tribes differ as to the degree to which they assimilate cultural elements. For example, the Comanche had no sun dance and a rather weakly organized camp, but otherwise had the typical traits. The Teton-Dakota, on

the other hand, seems to have all the before-mentioned traits in full function and for that reason the most typical, whereas the Comanche seem to stand at the other extreme.

Turning now to the eastern group, we find all of them cultivating maize and in most cases using a more permanent bark, mat, or earth-

THE INDIANS OF THE PLAINS.

The ranges for the various tribes are approximately indicated by the positions and extents of their respective names. As a rule, these tribes did not respect definite boundaries to their ranges, each tribe claiming certain camping places, but otherwise hunting and roaming where it pleased. The typical Plains tribes are designated by a star and range north and south across the area. To the east of them are the tribes practising some agriculture, perhaps in imitation of the Woodland tribes. On the west are a few tribes whose position is quite uncertain; hence the boundary for the culture area has been drawn through their range, thus giving them an intermediate position.

covered house. The most curious thing is that in this area this type of house seems to be associated with agriculture, because the houses are usually placed near the fields and occupied only during the planting season. In many cases, when not engaged with their fields, the whole tribe would take to tipis or other temporary shelters and roam about hunting buffalo. Even in midwinter, the Omaha and Santee-Dakota

left their earth and bark-covered houses to dwell in tipis. When out after buffalo many of these tribes used a camp and police organization similar to that of the typical Plains group. Other traits, such as the sun dance and sign language, occur but occasionally. The members of the typical group were neither potters nor weavers, but in the eastern group we find some weaving and some pottery, though not so highly developed as in the far east and south. Our eastern Plains group thus stands as an intermediate or transitional culture, between that of the typical buffalo-hunting Indian of the west and the typical sedentary Indian of the Ohio Valley.

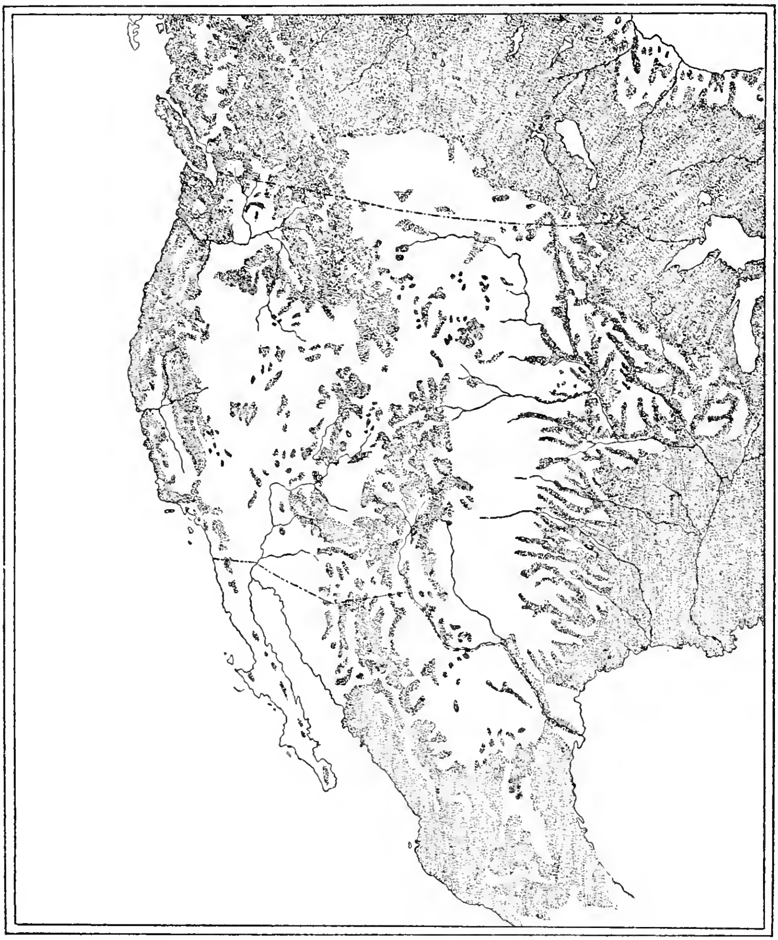
In the same way we could show that the tribes to the immediate west are transitional between Plateau and Plains culture, because they have traits common to both.

So far, we have considered culture alone. Anthropologists usually classify people in three ways: language, culture and anatomical characters. Strictly speaking, language should be included in culture, but because of the peculiar difficulties in linguistic research it is more convenient to separate the two. The tribes enumerated in the map speak languages belonging to seven distinct families (Siouan, Algonkin, Caddoan, Kiowan, Shoshonean, Athapascan and Shahaptian) and have more than twenty separate languages. Six of these seven families are found in other culture areas and in some cases widely distributed over the continent. As is well known, there is no apparent correlation between cultures and language, for should we superimpose linguistic and culture area maps there would be no significant correspondence. The same may be said of anatomical type.

We may now consider some of the important problems raised respecting the culture of the Plains Indians. Everybody interested wants to know how and when their culture developed, but all problems of this kind have proved particularly difficult, so that no one can yet say even approximately by what means cultures came about. On the other hand, we have sufficient data from some culture areas of the world to form some idea as to what went on therein within a given period of time.

Several more or less extreme theories have been proposed to account for culture. One is that, in the main, each group of people, independent of every other, worked out and created its own culture. The opposite view is that independent invention is extremely rare, so rare that we may assume all like traits as due to inter-tribal borrowing, or historical contact, until we find evidence to the contrary. The present tendency among American anthropologists is to take the middle ground and stand for empirical methods in that both may be true to a degree and that each culture is to be considered upon its own merits without regard to an initial assumption. To them it seems unnecessary to assume anything as to origin until there is real evidence lending itself to a particu-

lar interpretation. It is conceivable that a tribe may build up its culture by some independent inventions and by some borrowing from its neighbors, all of which may perhaps be revealed by the careful analysis of neighboring cultures and a comparative study of their traits. If we



THE DISTRIBUTION OF FORESTS IN WESTERN UNITED STATES.

The shaded portions of this map mark the areas originally covered with trees. The true plains extend from north to south along the eastern border of the Rocky Mountains. On the west, trees are found on the sides of mountains; on the east, they stretch out into the plains along the margins of the streams. Reference to the tribal map shows how the typical group ranges in the open plains while the eastern agricultural village group lives in the partially forested belt. On the west the plateau group appears to range in the open stretches among the mountains.

apply this method to the Plains we find an easy line of approach. Some years ago, Mr. Mooney published his objective study of the ghost dance religion, a curious religious movement originating in one tribe and

quickly spreading to several tribes of Plains Indians. In this case, there can not be the least doubt as the events are a matter of history. Again, at the present day the mescal ceremonies are working their way up from the south among the Plains tribes; this is also a matter of history. In addition to these absolute examples of cultural borrowing, we have cases like the grass dance ceremony, now found in all parts of the area. We have the testimony of several tribes to the effect that this ceremony first originated with the Pawnee. The Teton-Dakota claim to have obtained it directly from the Pawnee about 1870; the Arapaho and Gros Ventre claim to have borrowed it from the Dakota; the Gros Ventre claim to have taught it to the Blackfoot about 1883. While these statements of the Indians need not be taken as absolutely correct, their significance can not be ignored. There are still other traits like the sun dance which are found in the same essential forms among many tribes of the area, but concerning which the Indians have no definite historical knowledge. In this class also must be placed the more objective traits, like tipis and decorative designs. Now, since we have direct historic evidence of borrowing in some cases, the testimony of Indians in others, and still others in which we see all the secondary signs of borrowing, it must be admitted that a strong case has been made for the spread of culture by inter-tribal borrowing.

While borrowing will thus account for the distribution of traits, it can not answer the question as to their origin. For each trait we have a separate problem, since to be borrowed it must have been invented somewhere first. To solve this problem actual historical data are needed, something that is in most cases unattainable, but on the other hand, certain conclusions seem justifiable.

We note that many of the more material traits are peculiarly adapted to the bison-hunting life and to the habits of a semi-nomadic people. This seems reasonable, because many of them are rarely found outside of the Plains area. If this is granted, it seems proper to conclude that they must have been invented by some of the Plains group.

Another related problem is that of migration or origin. For the Cheyenne we have some historical data, the import of which seems to be that they migrated from the Woodlands to the Plains about two centuries ago, where they must have changed in culture very rapidly to become one of the typical tribes, as they were found to be in later years. It is also quite clear that the Sarsi, Plains-Cree and Plains-Ojibway came out of the northern and eastern forests into the Plains something more than two hundred years ago. As to other tribes, we have no data. There is ground for an assumption, however, in linguistic relationships. Some people say it will not do, for example, to say that the Algonkin tribes in the Plains migrated thither on the ground that the greater part of the stock lived in the Woodlands, for it is conceivable that the reverse may

have been true. On the other hand, since the most widely distributed stocks (Algonkin, Athapascan and Shoshone) have minor representation in the area, it seems unlikely that the Plains should have been the cradle land for all. The difficulty is to find proof for any one stock. Nevertheless, it seems reasonable to assume that some of the tribes came there by migration, bringing with them cultures of another sort, as did the Cheyenne and Plains-Cree in historical times. We should then have a period during which various cultural groups were introducing and adapting themselves to new conditions. The most reasonable theory, for the origin of Plains culture, therefore, is that it was the joint product of many tribes, some working out one trait, others again different traits, which by tribal contact and interaction were gradually diffused over the area. In other words, the culture as a complex was worked out by the Plains Indians themselves, but probably not by any one group and probably not without very material aid from tribes in other culture areas.

In some of the older literature we find the belief that there is a more or less steady upward trend in the affairs of man and that there comes a time in the careers of all peoples when they change from a nomadic to a sedentary agricultural life. While as a general principle it is clear that there must have been a time when agricultural groups changed their less sedentary life, it would not be correct to infer that the Plains Indians were always nomadic. Mr. Mooney has made a good case for the Cheyenne as formerly living in the fringed area to the east where they raised maize, but later moving out into the Plains and becoming one of the strikingly typical hunting tribes. In this case the change was radical. It is sometimes regarded as fair to assume that the Arapaho went through the same transitions, but there are no positive data. On the other hand, the Dakota may have followed the reverse process, though we can not be positive, for some of the early Jesuit writers say that in their day none of the Dakota were given to agriculture, while later observers found the eastern division, or Santee-Dakota, raising maize, beans and squashes. The tendency has been to assume that all the Dakota were once agricultural and that the Teton division abandoned the practise when moving west of the Missouri River. The chief objection to this view is that in some of the earlier literature we find evidence that the Teton themselves had no traditions of ever having practised the art. This taken with the positive statements of the Jesuits makes a good case. Further, we find that the tipi was used by all the Dakota as their chief dwelling and was by them so regarded, in spite of the fact that when tending their fields the Santee division resided in bark-covered cabins. This tendency to make the tipi the primary dwelling was quite widely distributed in the area and suggests that agriculture may have been but recently introduced to some of the buffalo-hunt-

ing tribes living along the fringe to the eastern forested area. We have then rather good evidence that cultural transitions went on in both directions within the Plains area. On one side were the typical non-agricultural tribes in the midst of buffalo, on the other were the forest tribes living in fertile valleys amid the trees with their small fields of maize; between them along the Mississippi, the lower Missouri, the Illinois, etc., were interspersed prairies and woodlands. Naturally, the people in this middle ground might take to alternating in buffalo hunting and planting, finally some going over entirely to the one or the other. Thus we had, no doubt for many decades, a shifting of culture influences, now in one direction, now in the other, and while we have here no evidence of a fixed direction of development we do have what may be taken as a typical example of how a people develop culture. In general, we believe that the facts warrant the assumption that the typical Plains culture was developed in the heart of the area and was the composite result of independent invention and the adaptation of intrusive cultural traits from the east, south and west.

HEREDITY AND THE HALL OF FAME

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WHAT is there in heredity? Ask the horseman, the dog fancier and the horticulturalist, and you will find that a belief in heredity is the cardinal point of all their work. Among animals and plants nothing is more obvious than the general resemblance of offspring to parents and the stock from which they come. With the highest-priced Jersey, the blue ribbon horse or a prize-winning dog, goes always the pedigree as the essential guarantee of worth.

So in the general bodily features of human beings, no one questions the great force of inheritance or is surprised because those close of kin look very much alike. Similarities in eyes, nose, mouth, complexion, gestures or physique are accepted as a matter of course, and we never stop to wonder at what is in reality one of the greatest of all mysteries, the substantial repetition of the same sort of beings generation after generation. If heredity does so much in moulding the physical form, may it not do as much in determining the shape and quality of the brain, in short, the mental and moral man in his highest manifestation of genius—indeed the ego itself?

Here we find differences of opinion, for man usually thinks of himself as in part at least a spiritual being, free to act according to his own will, unsubject to the laws of matter. In addition there is the fixed belief in so many quarters, that in the development of character and personality surroundings are of the first importance.

Thus heredity, environment and free will may be called the three rival claimants in the causation of mental and moral traits.

The last two have had many supporters, especially among philosophers and theologians. All the great schools of the past have taught that man's proneness to good and evil was either a fixed principle implanted within him without reference to heredity, or else was something to be modified by an effort of the will or by the influence of surroundings.

The advocates of environment have been, and still are, numerous, especially among the educators and all those who hope to make over the world by drastic reforms, or are interested in improving the condition of the lower classes.

Who then are the advocates of heredity? This view has been largely championed by the scientists and is of comparatively recent de-

velopment. The Darwinian law of the origin and descent of man has undoubtedly indirectly contributed to a growing belief in the force of heredity and has acted as a stimulus to its more exact study. Scientists are assembling facts, and making accurate measurements where once they were content with vague arguments and theories.

The writings of Sir Francis Galton show that among Europeans a large percentage of the most eminent men (about half the entire number) have been closely related to other more or less eminent persons. This, however, leaves the question open how far unequal opportunities, differences of education, and social influence may have favored the close relatives of distinguished men.

In Europe the caste system counts for much, and family patronage may be thought to be at the bottom of many a public recognition of distinction. But it can not be due to anything characteristically European that so many of the great men of the older civilizations of the world are so often connected with others of the same type. For what are we to say when the truth becomes discovered that right here in America under our free and democratic institutions the same facts are to be found?

Galton mentions only three or four Americans, but a careful analysis of our own history speaks no less strongly for the inherited nature of exceptional ability.

The Lees of Virginia, the Livingstons of New York, the Adamses, Quincys and Lowells of Massachusetts, all illustrate the force of hereditary intellect. It is claimed that there are no less than 1,400 superior Americans descended in a direct line from Jonathan Edwards, the great philosopher of Puritan New England, whose blood has run through thirteen college presidents, sixty-five professors, and many principals of important academies.

The Edwards blood has produced more than one hundred lawyers, thirty judges, and some sixty more have attained distinction in authorship, the latest being Mr. Winston Churchill, of New Hampshire. They have been mayors of New Haven, Cleveland and Troy, governors of South Carolina, Connecticut and Ohio, and many diplomats, congressmen, senators and one vice-president of the United States are recorded among their number. Railways, steamship lines and banks have also claimed their talent, but in general Edwards traits have found their outlet in professional life.

The two most notable families in America, considering descent in the male lines alone (the remarkable Edwards showing includes the female lines as well), are the Lees and Adamses, with the Lowells pressing close in third place. Taking into account international as well as local fame, probably Henry Adams, who settled in Braintree, Massachusetts, in 1632, has the honor of being the progenitor of more distin-

guished descendants in various male lines than any other American who has ever lived.

In Jameson's "Dictionary of United States History," and Lippincott's "Biographical Dictionary of the World" are included 13 Lees, 11 Adamses, 10 Lowells, 9 Dwights, 8 Trumbulls, 7 Livingstons, 7 Bayards, 6 Irvings, 6 Sewalls, 6 Prescotts, 5 Channings, 5 Edwardses, 5 Mathers, 5 Randolphs and 5 Winthrops, and over one hundred other families in which from two to four noted Americans can be found closely related to each other. This is without considering consanguinity through mothers and daughters.

When it comes to our greatest men, such, for instance, as are honored by tablets in the Hall of Fame upon the Hudson, more than half show eminent relationships on the above basis. Whether all names properly belonging in this most exclusive temple of the immortals have, or have not, been included, makes little difference in the present argument. No one can fail to pay homage to the names that are there. The 46 celebrities of the Hall of Fame have been selected only from those Americans who have been deceased at least ten years. They have been elected only after careful deliberation, the names of candidates being voted on by a committee of a hundred, made up of citizens well qualified to pass judgment on such matters. College presidents, historians, editors, financiers, scientists and chief justices form the committee. The next election will take place in 1915.

Now if the family history of these 46 preeminent Americans be carefully looked into, they show an extraordinary amount of blood relationships with other men not quite so celebrated it is true, but still men in every sense entitled to the term "eminent," and men whose lives and achievements have added to the luster of their country. Professor Jameson's "Dictionary of United States History" with Lippincott's "Biographical Dictionary of the World" together contain separate sketches for only about 3,500 Americans. There must have lived at least 35,000,000 adult persons from the first settlement of the country to the present generation.

It is very difficult to get any conception of vast numbers of people or of figures in the millions. A considerable stretch of the imagination is necessary. Think of a line of men 35,000,000 feet long. Such a line of 35,000,000 men and women, standing one behind the other in single file, would stretch from the Capitol at Washington to San Francisco, and then bend up to Alaska. In such a line of fame, George Washington, by common consent, as the Father of his Country, stands number one and Abraham Lincoln stands number two. All those within the "3,500 group" would be standing well within one mile of the dome of the Capitol, while the 46 elect of the Hall of Fame would be within the rotunda itself. This means that all those in the "3,500 group" are as one in 10,000 of the entire population.

Suppose the average man or woman to have as many as twenty close relatives—as near as an uncle or a grandson. There can be then only about one person in five hundred who can claim close relationship to an "eminent" man. Those whose names are in the above dictionaries are, on the contrary, related to each other to the extent of about one in five. If the more celebrated among these be alone considered, it will be found that the percentage increases so that about one in three is related to some one within the group. This ratio increases to more than one in two when the families of the forty-six Americans in the Hall of Fame are made the basis of study. If all the eminent relations of those in the Hall of Fame are counted, they average more than one apiece. Therefore, they are from five hundred to a thousand times as much related to distinguished people as the ordinary mortal is.

The following great Americans whose names adorn the Hall of Fame show eminent relationships according to the test.

George Washington was the uncle of Bushrod Washington, justice of the Supreme Court of the United States.

Thomas Jefferson came from plain people on his father's side, but his mother was of the old and distinguished Randolph family. The great orator John Randolph, of Roanoke, was his second cousin, but is too far removed to be counted as a "close" relation. Jefferson's daughter Martha married Thomas M. Randolph, governor of Virginia, and their son, Gen. George Wythe Randolph, counts one "close" relation mentioned in the dictionaries of history.

John Marshall, the greatest American jurist and one of the great jurists of all time, is connected with one of those in the second (or 3,500) group. His nephew, Thomas F. Marshall, reached eminence as a judge and member of Congress. "As a political orator and wit he had great fame."

Abraham Lincoln was the father of Robert T. Lincoln, secretary of war, minister to Great Britain and president of the Pullman Company.

Daniel Webster was the son of Judge Ebenezer Webster, prominent during the Revolution. Daniel's brother "Ezekial acquired a high reputation as a lawyer."

Benjamin Franklin had no great ancestors, but his talents were well transmitted to his descendants. His illegitimate son, William Franklin, became a man of prominence and was the last royal governor of New Jersey. But the more brilliant qualities appeared especially in the Baches of Philadelphia, descendants of Franklin's daughter. Alexander D. Bache was one of the foremost of American scientists.

Alexander Hamilton came of aristocratic lineage on his mother's side; on his father's side, his people were merchants. He married a daughter of General Philip Schuyler, whose mother was a Van Rensselaer. Many of his descendants have become distinguished. John

Church Hamilton and Major-General Schuyler Hamilton satisfy the criterion here imposed.

Few people realize that Washington Irving was one of six Irvings, all distinguished in authorship—three brothers and two nephews of the author of Rip Van Winkle. Washington Irving, therefore, counts five eminent close relations according to the test.

Louis Agassiz, one of the few great Americans of foreign birth, was the father of Alexander Agassiz, who also reached eminence in natural science. Besides conducting many researches of a purely scientific nature, such as deep-sea dredging and archeological explorations, he served the cause of education by princely gifts to the Museum of Comparative Zoology at Harvard; money which he had himself made through developing the now famous Calumet and Hecla copper mines. Alexander Agassiz received the highest honors in the American scientific world, inasmuch as he was president of the National Academy of Sciences and also president of the American Academy of Arts and Sciences. He was also given the Order of Merit by the German emperor.

Jonathan Edwards, America's greatest metaphysical thinker, was one of a great group of interrelated eminent Americans. He is of the first magnitude in a galaxy of stars. With grandfather, son and grandson, he is surrounded by these luminaries of the second rank.

S. F. B. Morse, inventor of the telegraph, is the center of a small and isolated cluster. His father, Jedediah Morse, D.D., is considered "the father of American geography." A brother, Sidney Edwards Morse, won fame as an inventor.

Henry Clay belonged to the distinguished Virginia Clays. Of his four sons who reached maturity, one son, James B. Clay, enters the 3,500 group. He was a member of Congress and prominent politically. He died in 1864, aged forty-seven.

Peter Cooper, the wealthy New Yorker, who was elected to the Hall of Fame as a representative philanthropist, was the father of Edward Cooper, who was mayor of New York from 1879 to 1881 and 1883, and is remembered in history on account of his activity in the overthrow of the "Tweed ring."

Oliver Wendell Holmes was the son of Rev. Abiel Holmes, pastor of the First Congregational Church, Cambridge, Massachusetts, from 1792 to 1832, who in 1805 published "American Annals," the result of great industry and research. "We consider it," says Professor Sparks, "among the most valuable productions of the American press." The son of Oliver Wendell Holmes, the poet, is Oliver Wendell Holmes, of the Supreme Court of the United States.

Robert E. Lee, as every one knows, belonged to one of the most distinguished families in America. Many of his relatives are the sub-

jects of separate biographical articles, those close of kin being his father, one nephew and one son.

James Kent, the celebrated jurist, was the father of William Kent, judge of the United States Circuit Court of New York, a lawyer who gained a high reputation.

Henry Ward Beecher was a son of the noted Rev. Lyman Beecher and was one of five distinguished brothers and sisters, among others, Harriet Beecher Stowe, author of "Uncle Tom's Cabin," herself an elect of the Hall of Fame as of first choice of the electors of 1910.

Joseph Story was called "the most extraordinary jurist of his age." His son, William Wetmore Story, gained most of his laurels in a very different channel. He is considered one of the few great American sculptors.

John Adams, second president of the United States, a member of one of the most notable families that America has produced, claims many distinguished relatives, if distant kinsmen be included. Samuel Adams was his second cousin. Dr. Zabdiel Boylston, noted physician, who was the first to introduce inoculation for smallpox in America, was his great-uncle. If only the close of kin be reckoned, then John Adams counts two in son and grandson.

John Quincy Adams, himself in the inner shrine of fame (elected in 1905), tallies as many as five of the "eminent" class. His position on the pedigree is at the center of the Adams group. With mother as well as father internationally famous, with a son, Charles Francis Adams, the bulwark, during our Civil War, of the rights of the United States in England; and with two grandsons reaching distinction in literature, John Quincy Adams rivals Beecher, Edwards and Lowell in the profusion of his lustrious kinships.

James Fenimore Cooper is not particularly affiliated to others of exceptional gifts. Still, his daughter, Susan Fenimore Cooper, became known as an author and philanthropist. She is in the group of 3,500.

James Russell Lowell had eight eminent close relations. His grandfather, Judge John Lowell, was a member of the convention which framed the constitution of Massachusetts, secured the insertion of the clause "all men are born free and equal" in the Massachusetts Bill of Rights. It is indeed rather ironical that this phrase should be coined by a Lowell. The poet's uncle, John Lowell, was an "able lawyer and political writer." Another uncle, Francis Cabot Lowell, was one of the principal founders of the city of Lowell, to which he gave his name. He was a merchant and manufacturer. The father of J. R. Lowell was Rev. Charles Lowell. Rev. Robert T. S. Lowell, brother of the famous poet, is also noticed in Lippincott's "Biographical Dictionary" as an author. Mary Lowell Putnam, "a distinguished polyglot linguist," was his sister. Her son, W. L. Putnam,

"gave promise of extraordinary genius." He was killed in the battle of Ball's Bluff, aged twenty-one. Another nephew, Col. Charles Russell Lowell, was killed in the Civil War, aged twenty-nine. "He was a young man of great promise," and already one of the most distinguished cavalry officers in the Federal service.

The poetical gifts of William Cullen Bryant showed themselves in a lesser degree in his brother, John Howard Bryant.

William Ellery Channing, one of America's most eloquent preachers, was a grandson of William Ellery, signer of the Declaration of Independence. Two brothers and two nephews of the celebrated divine became eminent in professional life.

General William Tecumseh Sherman counts one "eminent" relative in his brother John Sherman, senator and member of the cabinet.

George Bancroft, the famous historian, counts also one "eminent" relative through his father, Rev. Aaron Bancroft. The father was also noted as an author. Besides a great number of sermons, he published a "Life of Washington" which obtained great popularity.

Thus, 26 of the 46 men in the Hall of Fame show close eminent relationships. In total relationships, they tally 57, which, as already said, is from 500 to 1,000 times what random expectation calls for.

Much might be said concerning the families of others in the Hall of Fame, such as Emerson, Longfellow, Audubon, Eli Whitney, Phillips Brooks and J. Lothrop Motley, but they do not happen to show "eminent" relationships by the method here used.

All the above material has been collected in a systematic way, in order that its value may have a scientific and impartial basis. If the names of more or less distinguished relatives do not have separate articles devoted to them, in the afore-mentioned dictionaries, they have not been utilized in the above list. These two books have been used, not because they are considered infallible guides, but because they are convenient and are good enough for the purpose at hand. The same sort of result would be obtained if any good test were employed.

The proportion is the same the world over, for men of the highest caliber, one in two, or better, show relationship with other distinguished men, and these usually in their own field of activity.

The present writer has investigated the personalities and pedigrees of some 3,000 members of the royal families of Europe—published under the title "Mental and Moral Heredity in Royalty"—and has found that the same principles hold. Nearly all of the great names, or at least more than half, are closely associated by blood with those of similar stamp. About half of all the greatest rulers have been the descendants of comparatively mediocre ancestors; the other half have been the direct and immediate descendants of those as great or nearly as great as themselves. In other words, the vast horde (say ninety-nine

per cent. of the whole) is no more likely to produce a man of genius than is the one per cent. (or less than one per cent.) which, from the standpoint of eugenics, we rightly call the *crême de la crême.*

Thus we see why men like Lincoln and Franklin, who spring from the great reservoir of the commonalty, do not in the least upset one's belief in heredity, provided they do not occur very frequently. For they are the happy combinations of qualities derived from maternal and paternal sources.

All this does not deny that in some ways environment and, possibly, free will, play a measurable rôle in the determination of human fate, but it does suggest that the reliance which has been so freely bestowed on these social, institutional and metaphysical forces has been an exaggerated one.

The high percentages among illustrious men in this country—as high, in fact, as it is in Europe, is a very suggestive point. Opportunities are supposed to be freer in America, and social lines less strictly drawn. We should certainly expect to find in this country, notable names less often running in families; unless, of course, the eugenist's theory that it is nearly all a matter of heredity be indeed correct. At any rate, our much-vaunted American equality, liberty and opportunity have done nothing to make distinction in this country any less of a "family affair" than in the older civilizations of Europe.

THE MAN WHO DISCOVERED THE CIRCULATION OF THE BLOOD

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THE discoverer of the circulation of the blood was a London doctor called William Harvey.

The discovery of the circulation of the blood is the foundation of modern medicine; it was epoch-making, for it made possible that marvelous epoch in which we have seen the laws of living matter discovered and the actual, physical causes of the most mysterious diseases revealed. Harvey closed the dark ages of the science of the living; physiologically he "allured to *brighter* worlds, and led the way." Until it could be known that the blood, the same blood, moved round and round the body under the force of the propulsion of the heart, and that it traversed heart and lungs and all body-vessels in its closed circuit, there could be no physiology, no pathology, no therapeutics, no rational medicine: no such procedure as transfusion of blood. To understand what it was that Harvey discovered, we need to know what was believed as regards the movement of the blood before his time.

The oldest idea of all was that only the veins contain blood, the arteries air. Galen had corrected this latter mistake by tying a cord above and one below a length of artery and cutting out the piece above and below the ligatures; blood, of course, and not air was found inside. It was thought that blood went up and down the veins like the ebb and flow of a tide, that "crude" blood was made in the liver and taken to the heart to be purified. The heat supposed to be produced in this process was believed to make it necessary to cool the heart by drawing in air in the act of breathing, and this was regarded as the function of respiration even as late as the time of Haller, that is, the middle of the eighteenth century. The pulse or opening up of the arteries was regarded as an active thing on their part, blood not being forced into them by the heart but drawn into them by their own suction like a bellows draws in air. But Harvey said the heart is the pump, and the arteries are filled by its forcing its blood into them.

Harvey advanced not one or two but more like a dozen proofs of the circulation. His contention is—the blood in the arteries moves towards the tissues, thence towards the veins, it is collected in the right auricle of the heart, whence it flows to the right ventricle, this on contracting drives it through the lungs, whence it flows to the left auricle, passes to left ventricle and so is ready to be sent to the body again. Galen had

said that almost all the blood passed from the right to the left side of the heart across the septum of the heart, but Harvey, maintaining that the septum was not porous, proved that *all* the blood, not merely some of it, went round by the lungs.

Of course, this pulmonary or "lesser" circulation *was* taught before his time, notably by Servetus and M. R. Columbus; but it was Harvey who first showed that the valves of the heart and the valves of the veins absolutely prevent any other direction of flow except from the veins to the right heart and thence *via* the lungs to the left heart. This doctrine of the porosity of the septum died hard, for we find Harvey, towards the close of his life, attempting to convince an objector—Professor Riolanus—that if only he will pour water into the right heart and tie all vessels to and from the lungs, not one drop will get into the left ventricle.

No one before Harvey had fully understood the venous valves. His own professor at Padua—Fabricius—had talked a great deal of nonsense about them in a treatise entirely devoted to them. Harvey said that they were not primarily for supporting columns of blood, but for preventing any back-flow towards the periphery, seeing that they were present in the veins of the head in which the blood (under gravity) flowed past them with the greatest ease: here, since they *opened* towards the heart, they could not support any column of blood.

In Chapter II. of his great book—the "De Motu"—his chief point is, "the charge of blood is expelled by force," that is, the heart is dynamic for the circulation, a point by no means admitted before his time, for M. R. Columbus denied the heart to be even muscular. Harvey is absolutely clear on this point; he writes:

> It is in virtue of one and the same cause that all arteries of the body pulsate, namely, the contraction of the left ventricle.

Again in Chapter V. he writes:

> The one action of the heart is the transmission of blood and its distribution by means of the arteries to the very extremities of the body.

In Chapter VI. he gives a remarkably good account of the circulation through the fetal heart, that is, before lungs are developed; it is surprisingly accurate to have been done three hundred years ago. In Chapter VII. he returns to the circulation through the lungs and clearly arrives by induction at the existence of capillaries; the word of course he does not use, he calls them "porosities of the flesh," but he understands perfectly that arteries do not become veins without undergoing some complete change in structure and nature. He says if arteries became veins, there would be a pulse in the veins, marvellously good physiology for 1628!

Owing to his having no microscope sufficiently powerful, Harvey could not *see* the capillaries even in those transparent animals which he

scrutinized with his simple lens, but he inferred the existence of capillaries without ever seeing them. There are at the Royal College of Physicians in London three large boards on which he has dissected out the blood-vessels of the human body to the extreme limits which his scalpel would allow him. There they are to this day, a testimony to his eagerness to find those vessels in which the arteries ended. But it was not to be: I sometimes call these "tabulæ Harveianæ," his "sorrow's crown of sorows," for his finest dissection could not reach the capillaries. Three years after his death, in 1660, the great Italian naturalist, Marcello Malpighi, at Bologna, was the first of all men to see the living capillaries in the lung of the frog; he saw the blood coursing through them exactly as Harvey had predicted. Systemic capillaries were first seen in 1688 by Anthony van Leeuwenhoek, the Dutchman, at Delft.

Chapter VIII. contains the *epoch-making metaphor,* "motion as it were in a circle," "motion of the blood we may be allowed to call circular." Chapter IX. contains the argument from quantity, one of the subtlest in the whole book. It is a matter of very simple calculation to show that in an hour or two the heart will eject far more blood than the body possesses unless the blood comes back again to the heart: Harvey showed that the body of a sheep does not contain much more than about four pounds of blood, but that in an hour quite seven pounds of blood have passed through the heart. Now the heart can not deal with more blood than the body possesses, therefore blood is continually returning to the heart. Harvey, believing that the blood carried the nourishment to all parts, applied this view to an actual case of pulsating tumor which he had to treat: he tied the artery so tight as to stop the blood-flow to the tumor which shortly dried up from lack of nourishment. He had the full courage of his convictions; he applied his scientific knowledge to a surgical case for the relief of a suffering man. Chapter XVI. has the most interesting application of all; the argument based on the general or systemic effects of local absorption. Harvey points out that poisoned wounds, what we should call local infections, can poison the whole body; certainly this could not be so unless there was a carrying of the poison round through all the body, but that is just another expression for circulation. Were it not for the circulation, food absorbed where it is digested could never be distributed over the whole body: the circulation accounts equally for the universal distribution of food, drugs and poisons. Not until this was understood could there be a rational basis for physiology or the healing art; Harvey divides the empirical from the rational, for ever. In this way we may say emphatically that the discovery of the circulation was epoch-making, it brought in the era of experiment in biology, for Harvey experimented; had to do so in order to see nature at work; he tied this vessel and that, he looked into the body for himself; he was done with what Aristotle or Galen had said, done with library or arm-chair physiology.

> I sought to discover the motions and uses of the heart from actual inspection and not from the writings of others; at length, and by using greater and daily diligence and investigaion, making frequent inspection of many and various animals, and collating numerous observations, I thought I had attained to the truth, etc.

He says he has gone to work, "in order that what is false may be set right by dissection, multiplied experience and accurate observation." No short cuts, no shirking of trouble: no royal road to physiology. He goes on:

> Doctrine once sown strikes deep its root, and respect for antiquity influences all men. Still "the die is cast," and my trust is in my love of truth and in the candor of cultivated minds. Harvey was a gentleman.

Harvey demonstrated to any one who wished to see; to Hoffman at Nüremberg, to Vesling at Padua, to King Charles I., to whom he showed much: the king went with his physician to see a patient, a son of a Lord Montgomery, whose heart was congenitally exposed (ectopia cordis). Harvey dedicated his "De Motu" to the king.

Harvey did not apparently think of injecting the vascular system with some kind of colored liquid, as was done shortly after his death by several observers, notably by Ruysch of Amsterdam. But even had he so filled the vessels and therefore the capillaries, he could not, in the absence of all histological technique, have seen them in the opaque tissues. Harvey made the capillaries a logical necessity, Malpighi made them a histological certainty. But Harvey did much more than discover the mechanism of the circulation. He attempted with all the assiduity of his nature to discover the mechanism of reproduction and the course of development of the embryo.

Inexorably hampered by having no microscope wherewith to explore the ultravisible, Harvey nevertheless reached conclusions which have stood the test of time. He insisted that that small white speck on the surface of the yolk (the cicatricula) was the precursor of the chick, that the whole future animal came from a fertilized germ, and that every living being came from an egg (ovum). Such were by no means the views held by the majority of naturalists in his day; he was once more ahead of his time. Not until 1827, by von Baer, was the full truth of these things substantiated.

Harvey when Warden of Merton College, Oxford, where he was for two years when Oxford held out for Charles, associated himself with a Dr. Bathurst in experiments on development. Dr. Bathurst had hens laying eggs in his rooms in college, so that the embryo chick might be studied at any stage of its evolution.

Harvey furthermore wrote a treatise on respiration and one on insects; these, along with notes of post-mortem examinations (pathological anatomy), were all destroyed when his rooms in Whitehall were ransacked by the soldiers of the Parliament in 1642, an indelible stain

on the records of that assembly. With Newton and Carlyle, Harvey is in distinguished company as regards the destruction of manuscripts.

William Harvey, the eldest of the nine children (seven sons and two daughters) of Thomas Harvey and Joan Halke, was born at Folkestone on the south coast of England on April 1, 1578. Queen Elizabeth was at this time on the throne. His father was a prosperous yeoman, and in 1600 mayor of Folkestone. The Harvey family had not been a medical one; William was the only son who did not go into business.

There still exists a memorial brass to Harvey's mother in the parish church (St. Mary's) at Folkestone: she was only fifty years old at the time of her death. From a nephew, Daniel Harvey, are descended the noble families of Winchelsea and Aylesford. One of William's brothers was called Eliab; he became a Turkey merchant in London and managed his brother's affairs; for, like many geniuses, William was "constitutionally incapable of making a bargain." Eliab managed his money matters so well that William was always quite comfortably off. One of Eliab's descendants was Sir Eliab Harvey, G.C.B., who commanded the *Teméraire* at the battle of Trafalgar.

In 1588, when ten years old, Harvey was sent to the King's School at Canterbury, where he remained five years. It is thus perfectly possible that from his home on the English Channel he may have witnessed some of those engagements which led to the overthrow of the Spanish Armada, which occurred in August, 1588. When sixteen years old he entered Gonville and Caius College, Cambridge, on May 31, 1593. The entry is still to be seen in the records of that notable seat of medical learning founded by John Keys, the man who introduced into England from Italy the academic study of anatomy and the dissection of the human body as an essential means thereto. Harvey took his B.A. degree in 1597. As Harvey's father was a man of means, he could afford to send his son to study at the great University of Padua in north Italy, at that time and for long afterwards the most famous of the European schools of medicine. Harvey entered the University of Padua in 1598, and left it as doctor of medicine in 1602. The original of his doctor's diploma is in a glass case in the library of the Royal College of Physicians in London. I have had this priceless document in my hand; it is printed in the Latin language on vellum; the margins have been beautifully decorated by some artist in colors which are still perfectly fresh.

As an undergraduate, Harvey seems to have been a representative student, for he was elected three years in succession concilarius of the English nation, as it was called. The students at Padua were divided into nations for the purpose of voting for their rector, a system, for instance, only just abolished in the University of St. Andrews, Scot-

land. Padua recognized the English and Scottish nations as late as 1738. The MSS. lists of students for the sessions 1600–01 and 1601–02 begins with a "Gulielmus. Arveius. Anglus." These representatives of voting nations had the privilege of having their "stemmata" painted up somewhere within the university precincts. After a most laborious search, Harvey's stemma was found covered with whitewash on the concavity of the roof of the lower court-yard of the university. The master and fellows of Caius College have had it restored in its original colors; and very fine it is with a red ground, a white sleeve and green serpents; above it is the one word, "Anglica," and below it the three words, "Gulielmus. Harveus. Anglus." Precious words, for this is undoubtedly *our* William Harvey, then a youth of twenty-three years, who a little later was to reveal something which was to place his name beside the greatest names in the history of human discovery. He was soon to become an epoch-maker. But as a doctor of medicine later on he would be entitled also to have his coat-of-arms emblazoned somewhere in his alma mater. In March, 1893, after a most tedious search, the rector of that time discovered the shield with Harvey's arms, but so damaged that the inscription which accompanied it was lost for ever.

A few details are preserved to us of the social conditions at Padua in Harvey's time, and they show us a very miserable state of affairs. Food was scanty and bad, there was no glass in the windows, which were of linen; artificial light was extremely costly, and there were no public entertainments. The professor of anatomy was the venerable Hieronymus Fabricius ab Aquapendente, surgeon, anatomist and historian of medicine, a great favorite with the Venetian senate, who were the patrons of the chairs at Padua. The little theater in which he lectured at nine each morning from October to August still exists. It is of oval form, lined with oak, with steep-pitched, narrow platforms (instead of seats) with low rails to lean over to watch the dissection. There is a small cupola in the roof. It was not without some emotion that the present writer stood one September morning on the very spot where there came to Harvey the illuminating thought about the venous valves.

Harvey returned to Cambridge in 1602, when he at once took the M.D. degree at his English alma mater. By 1604 he had entered upon medical practise in London in St. Martin's parish; and on November 24 he was married in St. Sepulchre's church, Newgate, to Elizabeth Brown, daughter of Dr. Lancelot Brown, who had been one of the physicians to Queen Elizabeth. It was the bells of this same church that for many years were tolled on the morning of an execution in the prison of Newgate over the way. The Harveys had no children; his wife predeceased her husband.

In June, 1607, Harvey was elected a fellow of the College of Physicians, not yet Royal; and by 1609 he had been appointed one of the physicians to St. Bartholomew's Hospital, a charity justly proud to remember the fact. In 1615 he was made Lumleian lecturer at the College of Physicians, a post he held until 1656. In 1618 Harvey was appointed physician to King James I. and VI., and in 1631, physician-in-ordinary to King Charles I.

Lecture notes of Harvey's dated 1616, now in the British Museum, show that by that time he was teaching the doctrine of the circulation, but it was not till 1628 that he published with William Fitzer at Frankfort-on-the-Main a quarto entitled "Exercitatio anatomica de motu cordis et sanguinis in animalibus." An epoch-making essay this! and I am not forgetting either Schwann on the cell-theory or Darwin on the "Origin of Species." The "De Motu" is a good example of a great book which is not necessarily a large one; it has only 72 pages. Harvey published his book at Frankfort because of the important book-fair held there annually, so that the work might have a better chance of being rapidly taken up than if brought out in England, then vastly more isolated from the Continent than it is nowadays.

Possibly no epoch-making book had a worse reception. Previously to publishing the "De Motu," Harvey's practise was very large, for he was a skillful surgeon and obstetrician; but Aubrey tells us that after 1628

> He fell mightily in his practise; 'twas believed by the vulgar that he was crack-brained and *all* the physicians were against him.

Harvey was quite alive to the possibility of opposition and even dislike, so truly did he know that anything new is objected to, so difficult is it to overcome mental inertia. Listen to him:

> These views *as usual* pleased some more, some less; some chid and calumniated me, and laid it to me *as a crime* that I had dared to depart from the precepts and opinion of all anatomists. I tremble lest I have mankind at large for my enemies, so much doth wont and custom become a second nature.

He got what he expected, the usual treatment meted out to those who dare to upset what has been believed for a long time; people do *not* like to be disturbed physically or mentally.

From 1628 onwards, Harvey's spare time may be said to have been occupied in defending and expounding his so-called "doctrine" of the circulation, for both at home and abroad all the professors of anatomy were at first disbelievers. Harvey is most long-suffering towards that "tympanitic philistine," as Huxley called him, Riolanus of Paris. He is most courteous to him, he calls him "a learned and skillful physician, and the Corypheus of anatomists." Riolan was physician to Marie de Medici, mother of Louis XIII., and of Queen Henrietta Maria. Harvey met him once at Whitehall.

The great discovery had plenty of opposition everywhere, but I am

particularly sorry to have to say that the first person to write formally against Harvey was a Scotsman, a Dr. Primrose. He had been a pupil of Riolanus; he published his feeble tract in 1630. Harvey never replied to Primrose, probably because his book was sheer Galenism and because he had only just been admitted into the College of Physicians, Harvey being one of his examiners. This Dr. James Primrose was of the same family that gave rise to that of the Earls of Rosebery. A longer, but still weaker, protest was made in 1635 by one Parisanus, of Venice; Harvey did not reply to this, either; there was nothing new in it.

Caspar Hoffman of Altdorf was, in point of time, the next objector, as we gather from Harvey's letter to him dated May, 1636. Hoffman's difficulty is one very typical of the prescientific spirit, the spirit of the middle ages; it is this: Harvey has made out nature to be a clumsy and inefficient artificer in causing the blood to return again and again to the heart to be reconcocted. This objection we should now call teleological; Harvey's reply virtually is, that teleological difficulties must not prevent our drawing conclusions from facts observable in the living animal. Blood constantly pours through the heart in one direction only; if we can not explain this, that must not prevent our admitting that it does so. Harvey virtually says: you must not weight your physiology with a teological load.

The difficulty of Professor Vesling of Padua was neither frivolous nor antiquated, it was a real one: how is it possible for the blood in arteries and veins to be the same blood when it is scarlet in the one and purple in the other? This would be a difficulty to us still, if we did not know the physico-chemical reasons for the change of color. Naturally, Harvey's answer is not any explanation of the change of color; he can only emphasize the arguments of the "De Motu," which are so full and so convincing to those capable of appreciating the experimental method.

It can not be said that Harvey's life was destitute of incident, for his appointment as physician to Charles brought him into contact with many interesting and distinguished people, and led him into many stirring scenes. He accompanied Charles at least on one visit to Scotland, namely, that for his coronation in 1633. We know this, because there exists in the records of St. Bartholomew's Hospital a request for Harvey to absent himself, and that a substitute be allowed to act for him. Harvey was a very great deal with the king and accompanied His Majesty on his hunting expeditions, when he had opportunities of examining the bodies of deer, observations he turned to good account in his work on development ("De generatione").

It can not but be interesting to some of us to know that William Harvey was in Edinburgh. As personal attendant on the king, he

must have been at Holyrood and present at the banquet in Edinburgh Castle given by the Earl of Mar on June 17, 1633, in honor of the king. Charles remained two months in Scotland, from the middle of May to the middle of July, and we have a curious piece of incidental evidence that Harvey was with him all the time.

In his book on development, Harvey has left on record the appearance of the Bass rock "during the months of May and June" in a description he wrote of that island, which he visited for the purpose of studying the embryo in the eggs of the solan goose. His description of the myriads of these birds on the rock would be quite true to-day.

Harvey was at least once actually under fire in a battle of the civil war, namely, at the battle of Edgehill, where he had charge of the royal children, afterwards Charles II. and James II. Aubrey tells us that "a shot from a great gun" made them seek better shelter; we are also informed that Harvey read Fabricius on generation during the battle.

Harvey traveled a good deal on the continent of Europe; from 1631 to 1633 in Spain with the Duke of Lennox; while in 1636, in company with the Earl of Arundel, who was sent on a diplomatic mission to Vienna, he made an extensive tour which included Rome. They visited The Hague, Leyden, Cologne, Nüremberg, Lintz on the Danube, Baden, Ratisbon, Treviso and Venice. The records are still extant of the visit of the party to the English college at Rome; Lord Arundel was a Roman Catholic. To Dr. Weir Mitchell, F.R.S., of Philadelphia, we owe only this very year the publication of a number of previously unpublished letters written by Harvey on this journey to the Lords Feilding and Dorchester. They cast very interesting sidelights on men and manners; but we must not be tempted to linger over them.

At Florence Harvey and the Earl's party were entertained by that celebrated patron of learning, Ferdinand II., Grand Duke of Tuscany. At Nüremberg on this tour it seems almost certain that Harvey's portrait was painted by William van Bemmel. It is the portrait in which the heart and arteries are displayed in a dissection on the right of the figure. He was fifty-eight years old at this date.

A few of Harvey's more notable patients were: King James I., the Lord Chancellor Bacon, the Earl of Arundel, Prince Maurice, brother of Prince Rupert, a son of the Viscount Montgomery, Sir William and Lady Sandys and Sir Adrian Scrope.

Of his friends in England we know the following were of the number: the aged philosopher Hobbes, of Malmesbury; the Hon. Robert Boyle; Robert Hooke, F.R.S., the natural philosopher; Dr. Argent, Sir George Ent, Aubrey the antiquary, and Selden the lawyer.

Of three of his medical pupils—Scarborough, Willis and Highmore

—two have left their names embedded in anatomical nomenclature: in the circle of Willis and the antrum of Highmore.

It was in conversation with Boyle that Harvey admitted that the idea of the circulation came to him after pondering on the way in which the valves of the veins were placed with reference to the heart. Boyle's words are:

> When I asked our famous Harvey, in the only discourse I had with him, what were the things that induced him to think of a circulation of the blood, he answered me, that when he took notice that the valves, etc.

Now it is a very remarkable thing that Bacon in all his writings has not one word on the circulation, though its discovery was such an admirable example of the success of the inductive method he so laboriously recommended.

One other very great Englishman was a contemporary of Harvey, I mean the author of the plays and poems known as Shakespeare's. It has been conjectured that this very gifted person did know of the circulation and made allusion to it in his writings. Having looked into the question pretty carefully, I have come to the conclusion that this writer did not understand the circulation of the blood, although he had some acquaintance with anatomical terms and with the medicine of his day.

The champions of the Harveian "doctrine" were all foreigners, I suppose on the principle that a prophet hath no honor in his own country. The great philosopher Descartes convinced himself of the truth of Harvey's assertions by making a large number of dissections; but Descartes was not a medical man and not a teacher. Professors Sylvius of Leyden, Trullius of Rome and Bartholinus of Copenhagen were all ardent defenders of the Harveian faith. So enlightened a contemporary as Sydenham, the English Hippocrates, was not a convert. An admirable observer, he had, nevertheless, not a receptive mind; it was strong enough, but it was narrow. Alluding to Harvey and his school—the experimental one—he said:

> We *may* know the larger organs of the body, but its minute structure will always be hidden from us. No microscope will ever show us the minute passages by which the chyle leaves the intestine or show by which the blood passes from the arteries to the veins.

This is in his "De podagra" and his "De Hydrope" published in 1683. Sydenham was a little behind the times, for twenty-three years before Malpighi had, by the despised microscope, found the capillaries by which the blood of the arteries of the lung reaches the veins of that organ, and only five years after this statement was made, namely, in 1688, Leeuwenhoek, the Dutchman, discovered the capillaries of the general vascular system. So much for prophecy in biology when it is not based on a direct study of nature!

Some of Harvey's experiences were unique; he dissected the body of one of the oldest men that ever lived, Thomas Parr. Old Parr, a native of Shropshire, died in 1635, aged 152 years; he had lived under nine British monarchs. Harvey found no physical signs of senility in the body, no lime in the costal cartilages. He suggests that the sudden change from the old man's simple fare to the rich food of Lord Arundel's establishment was the cause of death. Harvey tells us that old Parr lived on sour milk and rancid cheese; he thinks he survived in spite of this diet, the followers of Metchnikoff would tell us that he lived so long on account of it.

Another of Harvey's curious experiences was the affair of the Lancashire witches. This reveals the gross superstitions that could flourish in 1634 and engage the attention of the king, a bishop or two, a secretary of state and the Lord Privy Seal. A boy playing truant in the woods in Lancashire swore that he had been carried off by a witch, Mother Dickenson. She bore him over fields and forests till she came to a barn where seven other witches were having supper when, he said, they assumed the shapes of all sorts of animals. This rigmarole and a great deal else was actually believed. The king commanded the Earl of Manchester to order a commission of medical men, one of whom was Dr. Harvey, to empower certain midwives to examine the bodies of these women, to see whether they had any marks on them indicating anything unnatural. The examination was carried out in Dr. Harvey's presence, and, of course, nothing was found. We have no scrap of evidence to make us think that Harvey in any way shared the popular superstition as to these women; he was merely carrying out the royal commands.

In personal appearance Harvey was of short stature; "of the lowest stature" and "little Dr. Harvey" are the phrases used to describe him. At thirty-seven years old, his hair was black; his eyes small and black. He seems to have been restless, full of energy, rapid of utterance, given to gesture and to playing with the handle of a small dagger he wore. His handwriting was exceptionally illegible even for that time. From all we can gather, his temper was irritable; "choleric" is the word used of him again and again. If this was so, Harvey wrote very courteously to his most tiresome opponents, as Professor Huxley has remarked. Seeing that he lived to the age of seventy-nine, and came through the fatigues that he did, he must have had a fairly good constitution.

Harvey was very fond of coffee, a beverage in his day by no means universally taken; and on his own confession he occasionally drank freely of spirituous liquors. In later life he suffered from sciatica and gout, that disease of the intellectual hierarchy. His grandniece told Dr. Heberden in 1761 that her great ancestor, in his later years, sub-

stituted sugar for salt in his food. This observation is rather interesting in the light of the modern notion that excess of common salt leads to a retention of sodium urate in the tissues; it looks as though Harvey had found this out by experience.

As regards portraits of this epoch-maker, we are fortunate in possessing more than one. I have mentioned the van Bemmel, the engraving of which by Houbraken is well known. The oil painting in the upper Library Hall of the Royal College of Physicians, represents Harvey in later life. It was painted by Cornelius Jansen and survived the fire of London. There is also a head by an unknown artist in the National Portrait Gallery in London; this is the portrait reproduced in the memorial edition of the "De Motu" (Canterbury, 1894). In the rooms of the Royal Society in Burlington House, there hangs another head, a portrait of Harvey done by Jan de Reyn; it is undated.

My learned friend, Sir James Sawyer, M.D., of Birmingham, England, points out an interesting difference between the styles of dress in the two portraits, the Jansen and the de Reyn; in the former the collar is that of a cavalier, in the latter of a Cromwellian. Harvey lived eight years under the commonwealth: and Sir James's inference is that he altered his dress to accord better with the more solemn taste prevailing during the period of Cromwell's power.

As regards statues of Harvey, there are only two in the open air in England, as far as I know. One in stone is high up on the pediment of the building of the College of Physicians in Pall Mall where he stands between Linacre and Sydenham: the other is of bronze on a high pedestal on Folkestone Leas; there he stands looking out across the Channel away to those lands where he received his inspiration and where he was first sympathetically understood.

In connection with Harvey's religious position, we have hardly any facts to go on. Some have surmised that because he travelled with the Earl of Arundel, Harvey also must have been a Roman Catholic. I hardly think that a papist would have begun his will in the words he does

> In the name of the Almighty and Eternal God. Amen! I do most humbly render my soul to Him that gave it, and to my blessed Lord and Saviour, Christ Jesus; and my body to the earth to be buried.

In any case, the prince of biologists can not be accused of irreverence, far less of atheism. Harvey was the very opposite of irreligious. Once and again in his writings he alludes to divine purposes and designs. He says when he first looked at the beating heart, its movements were so tumultuous as to be comprehended by God alone. Referring to the valves in the veins, he says they were so placed by divine purpose.

William Harvey died at Roehampton in Surrey, on the third of

June, 1657. From the only account we have of his last days, there is no question that he died of left cerebral hemorrhage, for he had aphasia and paralysis. In a death-mask made from the old bust in the church, the right eye is more closed than the left, which would agree with right-sided paresis.

He was buried on June 26 in the Harvey vault which his brother Eliab had constructed below the parish church of Hempstead only two years before. Hempstead is an ancient village seven miles southeast of Saffron Walden in Essex. The funeral was attended by the president of the College of Physicians and a deputation from the same, and by Aubrey, his biographer, who helped to place the body in the vault. Aubrey says he was "lapt in lead," and on his body in great letters his name, "Doctor William Harvey." Quite a number of the members of the Harvey family were buried in these curious mortuary cases. In 1847 the late Sir B. W. Richardson, on visiting the church, found the window of the vault broken and rain gaining access to the floor: the case containing Harvey's remains was cracked and a frog jumped out of it. Richardson rightly thought that this state of things was not as it should be. In 1878 the conditions were still worse; by aid of magnesium light and a mirror he managed to reflect some light into the case and convinced himself that some remains were there. Accordingly he obtained permission from Dean Stanley to have the shell re-buried under a glass slab in the pavement of Westminster Abbey beside the grave of John Hunter, Hunter his descendant, not according to the flesh, but according to the spirit of a seeker after truth. Owing to the Dean's death, the project fell through. In 1882 the tower of the church fell through the roof, and so Richardson thought the sooner that Harvey's remains were put into a place of safety the better. At the expense of the College of Physicians, a beautiful sarcophagus of white Sicilian marble was built in the north transept of the church just above the vault, and on St. Luke's Day, 1883, Richardson and seven other Fellows placed the old shell in the sarcophagus which bears this inscription.

The remains of Harvey, the discoverer of the circulation of the blood, were reverently placed in this sarcophagus in 1883 by the Royal College of Physicians of London.

On the wall of the chapel close to the tomb there is a bust above the family coat-of-arms and a Latin inscription, a translation of which I shall give here, as it is in no account of Harvey's life and because it is always interesting to know what the competent contemporary opinion of a man was. The translation I owe to the kindness of my learned friend, Professor Wallace Lindsay, M.A., LL.D., of the University of St. Andrews:

William Harvey, to whose honorable name all academies rise up out of respect, who was the first after many thousand years to discover the daily move-

ment of the blood, and so brought health to the world and immortality to himself, who was the only one to free from false philosophy the origin and generation of animals, to whom the human race owes its acquirements of knowledge, to whom Medicine owes its very existence, chief Physician and friend of their Serene Highnesses James and Charles, Monarchs of the British Isles, a diligent and highly successful Professor of Anatomy and Surgery at the College of Medicine at London; for them he built a famous Library and endowed it and enriched it with his own patrimony. Finally after triumphal exertions in observation, healing and discovery, after various statues had been erected to him at home and abroad, when he had traversed the full circle of his life, a teacher of Medicine and of medical men, he died childless on June 3 in the year of grace 1657, in the eightieth year of his age, full of years and fame.

The Royal College of Physicians, of which he had been president in 1654, benefited greatly under Harvey's will, but it had already found him a noble benefactor during his life. In 1651 he had built a library and a museum for the college at Amen Corner; and, as acknowledgment, the Fellows erected a statue of him in their hall which was destroyed in the fire of London. Harvey assigned to the college his patrimonial estate of Burmarsh in Kent, a donation which provided the salary of the librarian and keeper of the museum. He also instituted an annual oration in praise of the benefactors of the college, and provided for an honorarium to the orator and for the expenses of an annual banquet. The Harveian oration has been delivered each year since that time; it is considered one of the greatest honors that can be paid to a Fellow to appoint him Harveian orator.

Curiously enough, there is no biography of Harvey that can be called authoritative. The only contemporary account of him, for it can not be called a biography, is by his friend, John Aubrey, the antiquary, the same Aubrey who has left us *some* facts about Shakespeare. This is an unsatisfactory, slight, gossiping account written by a medical layman. Quite the best life of Harvey is from the pen of Mr. D'Arcy Power, F.S.A., F.R.C.S., in the "Masters of Medicine" series. To it I have been indebted for many facts. Although, therefore we have no complete contemporary biography of the greatest epochmaker in medicine, we can glean enough to show us in what esteem he was held by certain very different kinds of persons. Hobbes, of Malmesbury, placed him alongside Copernicus, Galileo and Kepler, and declared "he first gave the true science of the human body." In another book Hobbes wrote of Harvey, as "the only man I know that, conquering envy, hath established a new doctrine in his life time."

The highly acute and ingenious natural philosopher Robert Hooke, F.R.S., mentions Harvey's discoveries alongside those of Pecquet, Bartholinus, Willis and Glisson. The great Descartes in one of his letters writes of Harvey, thus:

> As to the circulation of the blood, *there* he has his triumph, and the honor of first discovering it, for which medicine owes him much.

Thomas Bartholinus, of Copenhagen, said:

The English physician to whom belongs the honor of having first shown that the course of the blood is nothing less than a kind of perpetual movement in a circle.

Elsewhere Bartholinus declared:

To have had the glory of discovering the movements of the heart and blood was enough for one man.

Haller, a very learned and discriminating authority, called the De Motu, "libellus aureus."

I must refrain from any references to allusions to Harvey in contemporary English verse: both Dryden and Cowley have lines on him, but they are very poor stuff indeed.

Nor have we to-night time to discuss the large question of the claims of the Italian naturalist, Cæsalpino, to the honor of the discovery, important as this undoubtedly is. Harvey's life and work is rather too large a topic for one evening hour, but perhaps enough has been said to let us have *some* idea of both.

The "De Motu" is the greatest single essay on a biological or medical subject ever given to the world. It ranks on an equality with those other epoch-making monographs of Jenner, Schwann, Darwin, Simpson, Pasteur and Lister. Harvey did for physiology what Newton did for astronomy: gave a generalization which put many isolated facts into their places. It revealed an astonishing unity of plan amid manifold diversities of type. So grand was the simplicity of the mechanism of the circulation that that alone was enough to tell him he had attained to a great truth. He saw the one design everywhere, in the heart of the chick as yet unhatched, in the humblest insect, in the stately deer in the Royal park at Windsor. Harvey's work was epoch-making, because he broke with tradition and because it was founded on an experimental basis. Although his name is not in the original charter-book of the Royal Society (it could not be as its date is 1664), all Harvey's intimate friends were Fellows, and there is no possible doubt but that Harvey *would* have been in the Royal Society, as he was in that earlier unorganized nucleus of it at Oxford. Though a professional anatomist, he studied structures to discover their uses. Just as one of Galen's books is the "De usu partium," so Harvey's masterpiece is "Concerning the Motion and Uses of the Heart and Arteries." Harvey is always physiologically-minded. Harvey was a great man in an age that produced many great men; he was not dwarfed by his contemporaries because they too were great. What Shakespeare and Molière are to the drama, what Milton is to poetry, Bacon to prose, Bunyan to allegory, Murillo and Rembrandt to painting, Wren to architecture, Grotius to international law and theology, Galileo and Newton to terrestrial and celestial physics (and these, all his contemporaries, are masters), such is William Harvey in the realm of the knowledge of the most important system in the bodies of living beings.

GREAT EROSIONAL WORK OF WINDS

By Dr. CHARLES R. KEYES

DES MOINES, IA.

As in the eighteenth century marine planation was one of the notable discoveries in earth-study, and as in the last century the theory of general peneplanation through stream-corrasion was one of the grander conceptions of the age, so the recognition of desert wind-scour as the principal among erosional agencies seems destined to take its place among the first half-dozen great and novel thoughts which shall especially distinguish geologic science of the twentieth century. Under conditions of arid climate, by which more than one half of the land-surface of our globe is profoundly influenced, eolian erosion appears to become, as recently aptly stated, more potent than stream-corrasion, more constant than the washings of the rains, more extensive and persistent than the encroachments of the sea. Both as a sculpturing power and as a sedimentative agent the wind is thus in every way comparable to erosion and deposition by river and by ocean.

That it is possible for the universal disintegration of the rocks to go on by means of insolation instead of through ordinary chemical decay, that general and rapid exportation of rock-waste takes place through the agency of the winds instead of through the movement of waters, and that on the land deposition of wind-borne dusts in terranes

Fig. 1. Typical Enisled Landscape, near Wonder, Nevada; displaying differential effects of general wind erosion.

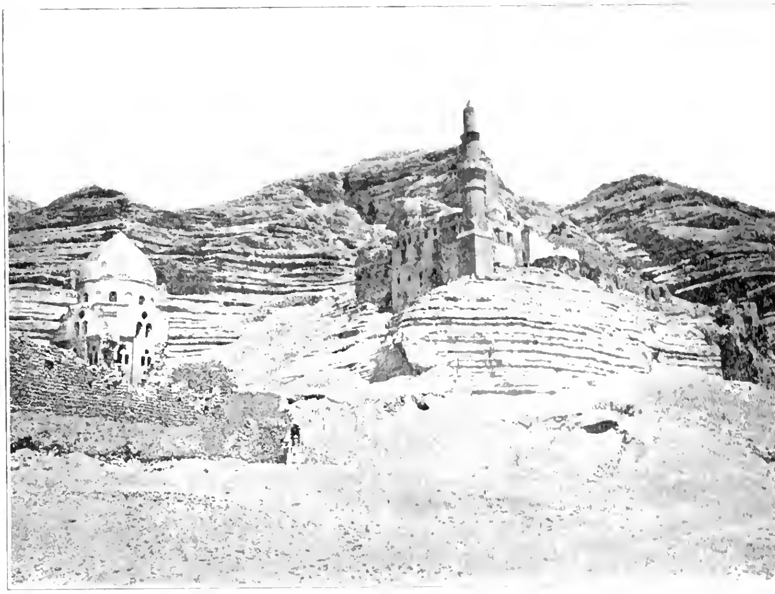

FIG. 2. WIND-GRAVED CLIFFS OF THE MOKATTAM HILLS; on the borders of the Arabian desert opposite Cairo, Egypt.

as mighty as any swept into the seas by streams or laid down on the floor of the ocean, are new and important generalizations belonging distinctly to the first lenstrum of our new century.

Prior to the year 1900 wind-action had been always regarded as merely one of the minor geologic agents of erosion—a mere idler in its manifestations, and a denuding power at all times negligible. That its real rôle in geologic economy had been so long so completely overlooked

FIG. 3. SHARP MEETING OF HARD MOUNTAIN ROCK AND SOFT PLAINS STRATA; Torreon, Mexico—a characteristic feature of regional eolation.

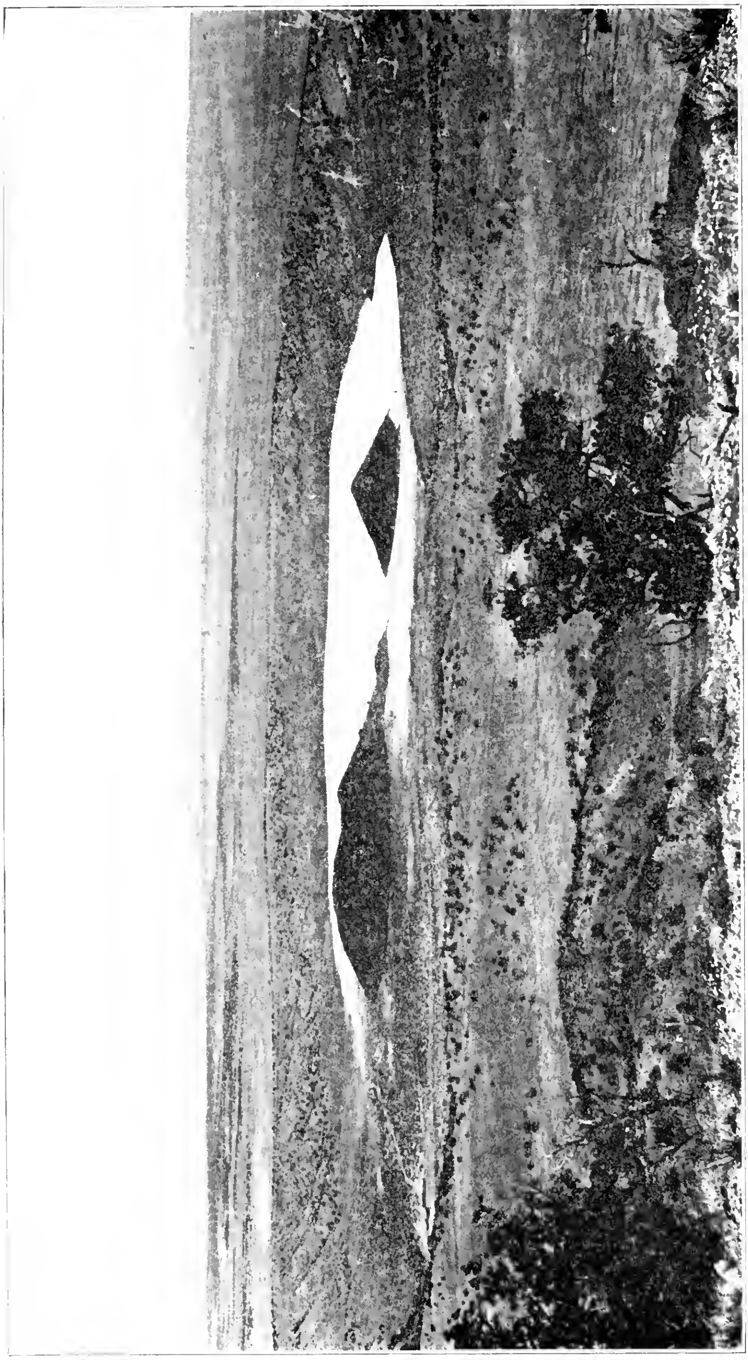

FIG. 4. INFANTILE STAGE OF A VOLCANO IN HIGH DESERT OF WESTERN NEW MEXICO; contest of two mightiest of earth powers to impress the local landscape.

appears to be due to the recency and enthusiasm with which by the scientific world the great law of the base-level of erosion had been received and to the vast dynamic possibilities which it had opened up.

Scant indeed is the attention given in the text-books on earth-history to the geologic effects of wind-action. A good and concise summary of our prevailing notions on the subject a decade ago is given by Udden. The great significance and value of the newer generalization lies not alone in the recognition of the geologic potency of wind-power as an agency of erosion, or as a means of forming such vast continental deposits as the loess, but of its tremendous efficiency as a general or regional denuding force. In far-reaching importance it compares favorably with the enunciation of the glacial theory of the last century.

It has long been the custom not only to treat the subject of general land-sculpturing independently of climatic considerations, but as if the molding of all landscape features was controlled by the same laws. The fertility of suggestion arising from the conception of a definite cycle of development through which all land-forms must pass has tended to exaggerate the evolutionary aspects of the theme at the expense of the genetic means by which the physiographic changes have taken place. Even the latest and most authoritative treatise on physical geography has premised the same derivation of physiognomy for the glacial Alps and the arid-high plateaux of western America, for the forest-clad Appalachians and the barren South African veldt, for the jungle-matted eastern Andes and the desert Australian interior. Ordinary stream-corrasion is made to account for all. Rain is regarded as the universal and sole graving-tool of land-sculpturing.

A full comprehension of the pregnant idea that wind-action under the favorable physical conditions imposed by arid climate is a general erosional agent may be said to date from the year 1904—the time of the appearance of Passarge's brief but quite remarkable essay on "Die Inselberglandschaften im tropischen Afrika." In various parts of the world during the decade previous the conception had in one way or another begun to assume form. The Trans-Caspian region had already furnished some facts bearing upon the new generalization. The vast deserts of the Dark Continent had supplied others. Our American arid lands had brought forth a host of still different suggestions. Indeed, as a definite working hypothesis the general scheme appears to have been first successfully formulated and applied in the great dry region of our own Southwest.

Whether first definitely outlined by American on the Girghiz steppes, by German on the South African plateau, or by Yankee on the Mexican tableland, it is certain that, as McGee astutely observes, the satisfactory disposal of the rock-waste of the desert by prodigious wind exportation furnishes the missing link to a rational explanation of all the long puzzling phenomena presented by arid regions throughout the world.

Fig. 5. Ortiz Laccolith, 5,000 feet high, unearthed from soft deposits 10,000 feet thick, by wind erosion mainly.

The distinctive feature of this great new conception of regional eolation is that under the favorable climatic conditions of aridity such as effect more than one half of the entire land-surface of our globe wind-scour is the chief agency of provincial lowering and leveling, far more rapid and efficacious than any general work by rain, river or ocean. To it are ascribed all the larger lineaments characteristic of arid lands. By it are graved the majority of desert details. It is the dominant sculpturing power in all excessively dry regions.

In a district undisturbed by mountain-making forces even plains are produced, smoother than any peneplain possibly can be, and yet

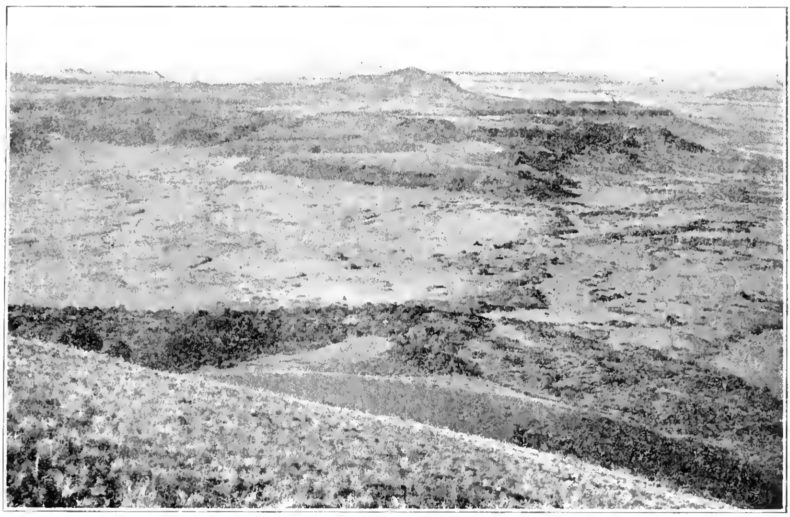

Fig. 6. Panorama of Lava-waste on Edge of New Mexican Desert; viewed from point 8,000 feet above plain; central butte 15 miles distant.

standing at a level high above that of the sea; such are the Kalihari and elevated South African veldt, recently so graphically described by Passarge, Bornhardt and others. Elsewhere, when open-patterned orogenic structure prevails, broad valleys and lofty flat-topped highlands persist, as in Turkestan, lately noted by Davis, Huntington and Friederichsen. Our own southwestern country, with its close-patterned structure, presents still other phases, remarkable as the most perfect of all typical Inselberglandschaften.

Singularly enough, the great law of the base-level of erosion, the most useful in all geologic science, had its birth under the cloudless skies of desiccated lands where in reality no vestige of its operations is discernible. The grand generalization applies strictly to land-surfaces under humid climates. Doubtless for this reason it is that none of our numerous government experts, in their fifty years' experience covering every part of the vast arid domains of the West, failed to perceive any-

FIG. 7. EXPANSE OF VAST DUNES IN HUECO BOLSON; the white sands of purest gypsum are blown out of great desiccating salinas.

thing of the potency of wind-action in the general leveling and lowering of the country. Of late years others who have traversed this field have caught occasional glimpses of deflative activity. Spurr notes certain minor aspects of it in the intermont basins of Nevada. Davis mentions others in Utah and Arizona. Cross calls attention to some notable phenomena in the San Juan district of southwestern Colorado that he mainly ascribes to wind-action. Hill describes still other features in northern Mexico. Free summarizes the literature on the action of the wind in the formation of soils. In none of these records of observation is the great principle of regional eolation recognized or even suggested. Through all of them the influence of the idea of peneplanation by water is overpowering.

No phase of land-sculpturing by water explains the peculiarities of desert relief. Where in humid lands are there such vast and even surfaces as the intermont plains of arid regions? Where under conditions of moist climate do such lofty mountains stand out so isolated as in our southwestern country—ideal monadnocks only theoretically and faintly suggested elsewhere? Where but in a dry climate does entire absence of foothills characterize the mountain ranges? Towering desert eminences rise out of elimitable expanse of level plain as volcanic isles jut from the sea. Plain meets mountain as sharply as the strand-line of the ocean. The rock-floor of the desert is often a plain itself worn out on the beveled edges of the strata beneath. The remarkable plateau-plains clearly represent former plains-levels. The soil-mantle is gen-

erally thin and gravelless; and all surface materials are transported. There is almost total absence of distinct waterways in the broad valleys. None of these relief characters bespeak of water-action of any kind. They all bear testimony of some erosive agency other than the one with which most of us are most familiar. Water can not do such geologic work. It seems to be a great advance in earth-study to be able at last to account satisfactorily for the formation of all those wonderful expressions on the face of the desert that have been so long so manifestly little understood or misinterpreted.

As in the case of ordinary general erosion, there are involved the three major processes of rock-weathering, transportation of rock-waste, and deposition of sediments, so in eolation there are the three corresponding phases termed insolation, deflation and aeroposition. Rock-weathering in the desert is peculiar in that there is practically no chemical decay going on at the surface. The destruction of rock-masses is accomplished by means of a process known as insolation—a constant flaking-off of rock fragments due to the great diurnal range of temperature so prevalent in dry climates.

The movement and exportation of fine rock-waste through deflation

FIG. 8. DESOLATE MAIN STREET IN MEXICAN ADOBE TOWN IN THE DESERT.

is now measurable to something of its true proportions. A "sand-storm" or "dust-storm" is really a strong desert air-current two or three hundred miles in width instead of a mile wide as in the case of the largest rivers, running forty miles an hour instead of three or four miles, and sweeping along a thousand times as much sedimentative materials. Only by such comparison is the enormous erosive potency of deflative action fully comprehended.

Wind-formed deposits are mainly laid down far outside the confines of deserts—in the moist verdure-clad lands, or in the sea. Their magnitude is very great, as the enormous loess formations, the vast expanses of black soils of the steppes and prairies, and the extensive adobe clays

FIG. 9. AN OASIS IN AN AMERICAN DESERT (SOUTHERN NEW MEXICO).

of many parts of the world amply attest. Continental deposits of this origin are just beginning to receive from scientists the attention which they merit.

The law of regional eolation will rank high among modern geological discoveries. What William Smith's discovery of characteristic fossils for identifying geologic terranes was to stratigraphy and historical geology, what Bunsen's theory of magmatic differentiation was to modern petrology, what Agassiz's hypothesis of continental glaciation was to recent geologic history, and what Powell's law of the base-level of erosion was to physiography of to-day, so the general theory of deflation, or regional eolation, is to the sciences of desert landscape sculpturing, and the formation of continental deposits as vast as any laid down on ocean borders. The theory adequately explains a grander host of

perplexing phenomena concerning the larger features of earth than any one of the great themes mentioned and perhaps more than all of them combined. It projects the imagination backward to the beginnings of geologic history; and it carries it forward to the end of time. In the lineaments of our dead moon it may be we behold the final effect of eolic powers.

Although perhaps not wholly the unaided work of any one man or group of men, the generalization of regional eolation is first distinctively American in origin. As such it seems not too much to say that it is allotted to stand as one of the far-reaching achievements of our century. It is doubtless the last of the great discoveries in geologic science to be attained by purely observational methods. The future advancements in earth-study must be quantitative instead of qualitative in character. They must be the direct outcome of mathematical investigation, of the rigid application of the new physico-chemical laws, and of the complete evolution which the discovery of radio-activity has imposed.

This, then, is briefly a statement of the theory of regional eolation.

HOSPITALS, THEIR ORIGIN AND EVOLUTION

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THE story of the birth and evolution of the hospital is a record of the conquest of barbarism by civilization and of the triumph of Christian altruism over the selfishness of the pagan ideal. Bargaining, trading, warring, the nations of the earth have struggled upward along the difficult highway of achievement, making slow but certain progress in the betterment of humanity. Always this approach toward the ideal has been characterized by an increased interest in the welfare of the public as opposed to the individual, and exemplified in unselfish efforts to befriend the sick and friendless.

No better index, therefore, of the progress of any nation in ethics and altruism can be obtained than a report of its work in the building and management of hospitals.

In its origin the word *hospital* comes from early Christian days when it was used to designate a place where strangers and visitors were received and cared for. Whether or not hospitals proper existed in pre-Christian time is a much-debated question. The fact has been established that the Egyptians studied medicine and that the sick were brought to their temples to be healed by the priests. To some extent this practise was observed by the Greeks and by the Romans in their temples of Æsculapius.

There is certain evidence of the existence in pagan Rome of *Valetudinaria*, or dispensaries, for sick soldiers and slaves; but of the existence of hospitals proper, houses of refuge for the poor and the ill, we have no proof. Something more than mere civilization was necessary for the establishment of these tokens of man's regard for his fellow man.

In India, a country whose ancient moral code was less pagan, if not more Christian, than that of either Greece or Rome, hospitals for men and animals are described by two early Chinese explorers. Prescott states that hospitals existed in Mexico before the Conquest, but his documentary proof is indefinite. Gaelic literature is rich in traditions concerning the House of Sorrow, a hospital for the wounded of the Red Branch Knights who lived about 300 B.C. at Tara, the palace of the kings of the heroic age of Ireland. But on sifting the evidence, we are justified in assuming that the claim of the pre-Christian hospital rests largely on tradition, while proof is abundant that these institutions were liberally encourgaed by the Christian Church.

There are many allusions in the New Testament concerning the healing of the sick, and Christ himself commanded his disciples to care for the ill and indigent. The practise of hospitality was enjoined as a virtue upon the early Christians; bishops, presbyters and deacons were especially obliged to practise this virtue and references to it are found in the Acts and most of the early commentaries. These documents tell us that in the bishop's house was a room set apart for the use of poor and ill travelers, designated as the *hospitalium,* or rest room. Harnack[1] states that the bishop was also required to act as a physician. In this *hospitalium*, therefore, in name as well as in function, we find the legitimate, though remote, ancestor of the modern hospital.

The many epidemics occurring in the Roman empire, as the epidemic of Carthage in A.D. 252, described by St. Cyprian,[2] gave those who would care for the sick abundant employment. Many a wealthier Christian imitated the bishop's good example and established a *hospitalium* in his own house. But, hunted and persecuted as the sect was, there could be no organization of this work; their efforts must remain desultory and scattered until the ban was removed. So it is that the advent of the public hospital comes after the reign of Constantine, when a great increase in the number of Christians and the spread of poverty had made adequate individual effort by the bishops difficult if not impossible.[3]

More than one writer has asserted that hospitals originated from three supposedly antagonistic influences, religion, war and science. This statement is not true for several reasons, but chiefly because history is opposed to it. There was plenty of fighting in pre-Christian days, but hospitals did not result from it. The Greeks had far more scientific knowledge than the Goths, yet the former did not build hospitals, while the latter did. Indeed, the real situation is outlined if we say that in the social ebullition produced among the nations of Europe by the introduction of Christianity, hospitals were the distillate and war and science the by-products.

The Christianity of the Lombards, the Goths and the Franks was a militant one. Scarcely had Clovis, the Frankish king, renounced his old gods than he commenced a holy war upon his unorthodox neighbors with the twofold object of converting them and obtaining dominion over their lands. In the dream of empire of the first great Charles the sword and the cross were close companions. Yet these early Frankish monarchs in the intervals between their wars were earnest in the building of hospitals. Long indeed after the hospital made its

[1] Harnack, "Medicinisches aus d. altesten Kirchengesch," in "Texte u. Untersuchungen," VIII., Leipzig, 1892.

[2] Cyprian, "De Mortalitate," XIV., in "Patres Latinæ" of Migne, IV., 591–593.

[3] Rom. XII., Heb. XIII., Peter IV., John III. Ep.

appearance came the university—so long, in fact, that the statement that the origin of the hospital owed much, if anything, to science is disproved chronologically. And this, too, without in the least minimizing the influence of the great medieval schools, such as Salerno and Montpellier, upon the hospitals of the middle ages.

But now to consider in brief detail the hospitals of early Christian era. We must first give our attention to the east, where the conversion of Constantine gave an impetus to the spread of Christian religion. Ratsinger[4] asserts that a hospital was established at Constantinople by St. Zoticus during the reign of the first Christian emperor, but his authority for this statement is mythical. We have, however, documentary proof in the writings of St. Gregory,[5] of Nazianus—whose brother, by the way, was a physician—of the establishment of a hospital by St. Basil at Cæsarea, in Cappadocia (A.D. 369).

According to Gregory, it was a veritable city with streets separating pavilions for various diseases and also workshops, industrial schools, convalescent homes and residences for attendants, nurses and physicians.

Indeed, the plan seems not unlike our most modern pavilion system; the ancient writer waxes enthusiastic in his praise of it, declaring it to be "a heaven upon earth."

Alexandria boasted a hospital in 610, founded by St. John the Almsgiver, and at about this same time Bishop Brassianus established one at Ephesus. Contemporaneous was the foundation in Constantinople of three hospitals, one by St. John Chrysostom, one by St. Pulcheria, sister of the Emperor Theodosius II., and one by St. Sampson. Thirty-five hospitals were erected in this one eastern city alone before the tenth century, according to the Constantinopolis Christiana of Du Cange. An orphanotrophium was established in the tenth century by Alexis I., and the Hospital of the Forty Martyrs by Isum II. in the eleventh century. Such was the influence of these Eastern institutions that we find their Greek terminology influencing the names of early institutions of the west. In all the writings of later days concerning hospitals a house for sick people is called a "noscomium," for foundlings a "orphanotrophium," etc. Perhaps one of the best proofs we have of the activity of the Christians in hospital building is the fact that the Emperor Julian, called the Apostate, decreed that hospitals should be built to offset the influence of similar institutions which the Christians had inaugurated.

St. Jerome[6] tells us of the hospital builded by Fabiola in Rome during the fifth century. Fabiola, a wealthy Roman lady, is probably our first Christian philanthropist. Pope Symmachus (495–514) built

[4] Ratsinger, "Gesch. d. kirchlichen Armenpflege" (Freiburg, 1884).

[5] "Patres," Migne.

[6] "Patres Lat.," Migne.

three hospitals in Rome during his pontificate, and these were maintained and additional ones built by his successors. But Stephen II. surpassed his predecessors in the eighth century by restoring four ancient institutions and building three new ones.

The Arabs, speedily changing from a barbaric army to a cultivated and civilized people through their contact with Greek thought in the countries conquered by them, were not long in proving their enlightenment by the standard of hospital building. The first Arabian hospital was built at Damascus A.D. 707 by the Caliph el Welid. Virtually the real rise of Arabian science came with the accession to power of the Abbasides (A.D. 750). The Arab by this time was a mixed nation, in which the Persian element seemed to predominate. Hospitals under medical supervision were not uncommon, although infirmaries predominated. Nuburger states that infirmaries existed in no less than fourteen cities, including Bagdad, Antioch, Jericho, Medina, Mecca—in short, throughout the entire empire. The part played by pilgrimages to places of devotion among Christian nations in the evolution of the hospital was perhaps even more pronounced among the followers of Mohammed. Clinical teaching was done in several of the large hospitals of Damascus, special attention being given to medicine and diseases of the eye. The hospital, mosque and orphanage founded by al Munsur in the thirteenth century was one of the most notable Arabian charitable institutions and is said to have had a staff of forty-two physicians.

Probably the earliest hospital in France was the "Xenodochium" for pilgrims, established by King Childebert in the sixth century. The practise of making pilgrimages to the shrines and holy places was a custom of the pious coming more and more into vogue, and the monarch's action was a much-needed charity to the sick and weary travelers. The Council of Orleans (549) gave this establishment hearty approval.

Many hospitals arose in France during this and the succeeding century. For at just this period the Franklish empire, more than any other European country, was slowly tending toward the conditions which made it eventually a nation of city dwellers, dimly foreshadowing what came later with the establishment of industries, the foundation of guilds and the influence of trade and commerce on national life. At Autin, at Athis, at Paris, Arles and Rheims, we have records of the establishment of hospitals by kings, nobles and churchmen. The oldest hospital in the world still enduring, the famous Hôtel Dieu, is attributed to Landry, Bishop of Paris, and its origin has been variously placed between A.D. 660 and 800. Lallemand's "Histoire de la Charité"[7] finds the first extant written mention of it in a document of 829. This began as a cathedral hospital, and was one of a group of institutions growing up about the old churches, which, developing into small com-

[7] "L'Histoire de la Charité," II., 112, Paris, 1902.

munities, formed the nucleus of many of the larger cities of the feudal period. Undoubtedly of much earlier origin was the Hospital Scothorum, which was built on the continent at a remote period by missionary Irish monks. This was destroyed and later was restored by order of the Council of Meux (A.D. 845). These were probably the same monks who founded the monasteries of Bobbio and St. Gall, and carried the art of illuminating manuscripts as well as the gospel itself to the semi-barbarous peoples beyond the Alps.

The idea of medical missionary work is not a new, but a very old, idea. Barbarous Europe was converted by medical missionaries; practically all of the monasteries of the monks of the west did hospital work.

This monastic influence reached its zenith in the tenth century, and the most famous hospital-monastery of that day was the Benedictine abbey of Cluny, founded in 910, and commanding not only a local reputation, but famed through Italy and France.

Originally each monastery had its infirmary for inmates, and this under the laws of hospitality was open to sick travelers. Before long the crying need of medical aid extended the ministrations of the infirmary to the people of the neighborhood, or to any who might seek it. The monastery was the repository of medical as well as all other written knowledge of that period, and it has been proved that among the profane authors copied by the monks in their scriptoria were some of the classical authors on medicine.

We must not imagine that the cathedral hospital languished during the preponderance of monastic medicine; according to Virchow, 155 hospitals were founded in Germany alone from 1207 to 1577. With the growing importance of the hospital it is no surprise to find religious communities springing up whose chief and surpassing occupation was to be the care of the sick. The first of these was organized in Siena, a cradle of Italian genius, during the ninth century. Soror, the founder of the hospital of Santa Maria de la Scala, drew up the rules for its administration with his own hands. The management was largely in the hands of citizens, subject to the bishop's control. Many such communities were established in Italy and lived under the rule of St. Augustine.

From this time onward the religious orders strongly influenced hospital development. In the twelfth century the Beguines and Beghards were hospital orders which flourished especially throughout Belgium, France and Germany, while the Alexians and Antonines established and managed hospitals in various parts of Italy as well. Leprosy following in the wake of the crusades, special communities were formed to care for lepers. Thousands of leper houses arose in all parts of Europe—it is estimated that 2,000 existed in Germany alone. The plague was eventually stamped out, an achievement in a public health

campaign which would do credit to a much more enlightened age. Special communities also isolated and nursed cases of erysipelas known as St. Anthony's fire, St. Francis's fire, etc. But the most important event in the history of hospitals in the period we must now consider, the middle ages, was the foundation of the order of the Holy Ghost, resulting, as it did, in a golden age of hospital building extending from the thirteenth to the fifteenth century and not equaled again till the hospital renaissance of the nineteenth century.

In the middle of the twelfth century Guy of Montpellier established the Hospital of the Holy Ghost in the city of his name. Montpellier was at that time the medical mecca of Europe and attracted students from remote cities. Not only the reputation of the hospital, but the order itself spread rapidly through France, building and managing hospitals.

Innocent III., the great militant pope, who did so much to strengthen the temporal power of the pontiff, had recently builded a hospital in Rome. It was characteristic of his genius that he foresaw the need of hospitals and the great work they might accomplish. He determined to promote their building not only in Rome and the Papal states, but also wherever his influence extended. To this end he summoned Guy to Rome and gave him charge of the new hospital of Santo Spirito. Visitors from all parts of the world were shown this hospital and encouraged to establish similar ones in their own communities. The object lesson served such a useful purpose that very soon hospitals were arising in every city of importance in Europe. The "Benificienza Romana" of Querini gives the names of thirty hospitals founded in Rome itself from the eleventh to the fifteenth century.

The part played by the crusades and the military and hospital orders in the evolution of hospitals can not be overlooked. Disease and pestilence were more potent in defeating the crusaders than the swords of the Saracens, and the military hospital orders found abundant employment. The Knights of St. John, an order founded to care for the sick and wounded, maintained after the conquest a hospital at Jerusalem said to accommodate 2,000 patients. Many priories were established in various parts of Europe while the order flourished. At first the knights acted as nurses and physicians to the sick crusaders; the military features of the order developed later. The organization became very rich and powerful in the course of time, and, swerving from its original purpose, degenerated and finally fell into disrepute. The Teutonic order, an organization of German knights banded together for labor in the Holy Land, did splendid work in building and managing hospitals. Many German hospitals were under its control and, unlike the Knights of St. John, it adhered closely to its original purpose. War and consequent financial reverses caused its dismemberment.

With all these institutions builded by popes, bishops, monks and crusaders, it would seem too soon to look for city hospitals. Yet very many such arose after the first crusade. Eastern commerce flowing in the wake of the crusaders, an increased national wealth and an increased population furnished both the resources for and the need of municipal and privately endowed institutions. Privately endowed hospitals are found first in Italy, and during the twelfth century Monza had three and Milan eleven such institutions. During the fourteenth century Florence had thirty private foundations. Some of the founders were notable people; the Santa Maria Annunziata in Florence was founded by Falco Portinari, father of Dante's Beatrice, and one of the Milan institutions by the Duke Francesco Sforza. In Germany during this period fifty-two city hospitals existed, sixteen being situated in Cologne, the remainder in about thirty smaller cities, the names of which are enumerated by Virchow.[8]

Various abuses began to creep into hospital administration during this period of prosperity which later caused trouble to ecclesiastical authorities, until some of the hospitals, while still conducted by religious orders, were placed under civil authority, the church still paying for their maintenance. In Italy, toward the end of the middle ages, this tendency grew more marked; in France it came considerably later, although the same conditions existed. It was in the fifteenth century that the Hôtel Dieu showed such gross mismanagement that the ecclesiastical chapter of Notre Dame, feeling its inefficiency to cope with the situation, requested the civil authorities to take over the hospital (April, 1505). It was thereafter managed by a board of eight trustees.

The ancient hospitals in Great Britain and France were for a long time under the control of the monastic orders. According to Harduin, a large hospital was founded at St. Albans in A.D. 864. Alcuin, the great scholar, who afterwards was called to the court of Charlemagne to preside over the School of the Palace, wrote to the Archbishop of York (796), and urged the foundation of hospitals for the poor and for pilgrims. The oldest hospital existing to-day as a foundation is St. Bartholomew's in London. This was established in the twelfth century by Rahere, at one time a jester to King Henry I., who later joined a religious community and secured a grant of land near London. Until its disestablishment under Henry VIII. this was the leading London hospital. St. Thomas' hospital, founded in 1215 by Peter, bishop of Winchester, suffered a similar fate, but was reestablished by Edward VI. Among other important hospitals of London belonging to the thirteenth century were Bethlehem, which later became an insane asylum and had its name contracted to Bedlam, Christ's Hospital and the Bridewell, the latter later becoming a prison and the former a school.

[8] Virchow, "Abhandl.," Vol. II., 16. See footnote 10.

There were many other hospitals in England during the middle ages outside of London, and Dugdale in his Monasticum Anglicanum enumerates 460 and gives the charters of many of them.

Prior to the sixteenth century seventy-seven hospitals were founded in Scotland and over twice that number in Ireland. The green island gives testimony as to the existence of hospitals not only by her law-code, the Brehon laws, but also by the perpetuation of such place-names as Spidal, Spital and Hospital. The Brehon laws are specific regarding hospitals, stating that the hospital must be free from debt, must have four doors for ventilation and that a stream of water should run through the middle of the floor. Dogs, fools and scolding women must be kept away from the patient. Whoever injures another must pay for the maintenance of the injured one in the hospital or private house and also for the maintenance of the mother of the injured one, if she should be living.[9] The Knights of St. John established several priories in Ireland, the most important one being Kilmainham priory, founded in 1174 by Strongbow. The Crutched Friars or Crossbearers flourished during the twelfth century and erected many hospitals. There are records of thirteen hospitals founded from this time onward which were confiscated in the strife following the reformation. That a number of leper-houses existed is attested by documentary references as well as by place-names.

Before we pass on to the modern epoch, a consideration of the character and discipline of these medieval hospitals will be of value. With a view probably toward facilitating drainage many of these hospitals were built near a river, as the Hôtel Dieu, on the Seine; the Santo Spirito of Rome, on the Tiber; St. Francis, in Prague: on the Moldan; and Mainz, on the Rhine. Many of these early hospitals were small, especially those privately endowed, and contained only about fifteen beds; others were planned by able architects, and on a large scale. The main ward at Santo Spirito, in Rome, was 409 feet × 40; at Tonnere 260 × 60; at Frankford 130 × 40. All these hospitals had numerous windows for ventilation, and some a cupola. The interior was usually decorated with great skill and care. Says Gardner, in his history of Siena:

> The hospital at Siena constitutes almost as striking a bit of architecture as any edifice of the period and contains a magnificent set of frescoes, some of the fourteenth century, others later.

The Tonerre hospital, previously referred to, founded in 1293 by Margaret of Burgundy, sister-in-law of Louis IX., was situated between the branches of a small stream, and its ward was lighted by many large windows extending high up in the walls. A narrow gallery ran along the wall twelve feet from the floor for the regulation of ventilation

[9] Joyce, "A Social History of Ancient Ireland," London, 1903, I., 616 et sq.

through the windows and the seating of convalescent patients in the sun. The beds were separated by low, wooden partitions which were portable, making the alcoved recesses part of one large hall at will, so that when mass was celebrated in the center of the building the altar was visible from all parts of the ward.

Mr. Arthur Dillon, an architect, whose scholarly article on this hospital appeared in 1904, says of its construction:

> It was an admirable hospital in every way, and it is doubtful if we to-day surpass it. It was isolated, the ward separated from the other buildings, it had the advantage we so often lose of being one story high, and more space was afforded each patient than we can afford.

Now as to the management of these medieval hospitals. In the monasteries the superintendency was in the hands of the abbot or prior and the institution was subject to monastic rule. Even in the privately endowed hospitals practically all the hospital attendants were members of some religious community. How well these communities did their work and with what real humanitarian zeal is attested by Virchow.[10]

In the military orders, the knights called their chief administrative officer commander; in the city hospitals this officer was called magister or rector. The rector was appointed by the bishop, the municipality or the patron. Laymen were eligible for this position and in many legacies lay control was stipulated as a condition. This rector was obliged to take inventories, render and keep accounts, act as trustee for hospital property and frequently to receive and assign patients.

Usually the attendants were males, although in some hospitals male nurses had charge of surgical cases, while females conducted the obstetric and children's wards. Board and clothing were provided these nurses, but no salary. Details of dress, food and recreation were rigidly prescribed, with appropriate penalties for infractions of the rules.

Patients were admitted from all classes and beliefs without qualification, and once admitted the patient was treated as a master of the house, "quasi dominum secundum posse domus," to quote literally from the regulations. He was bathed, his ills attended to, and if a Christian was confessed by the chaplain.

The regulations specified that the sick should never be left unattended, that nurses should be on duty at all hours of the day and night, and that patients dangerously ill should be removed from public wards to a private room. Santo Maria Nuova, at Florence, had a separate ward for delirious patients, and maternity cases were attended in a separate pavilion and kept in the hospital for three weeks after delivery. Sound hygiene is evidenced in numerous regulations concerning changes of bedding, ventilation, and heating by stoves and braziers.

[10] "Gesammelte Abhandlungen aus dem Gebeite der "Offentlichen Medecin und der Seuchenlehre," von Rudolph Virchow, Berlin, 1879, tr. in "The Popes and Science," Jas. J. Walsh, Fordham University Press, 1911, pp. 256, 263.

The revenues of the hospitals were derived usually from endowments, either given as private bequests or by church authorities. In times of unusual need special taxes were levied on commodities such as oil, salt, wheat, etc. Some hospitals owned houses, farms, vineyards and even whole villages as sources of income. Various societies and guilds were also established in aid of hospitals, and frequently diocesan laws required the clergy, especially the canons of cathedrals, to contribute. The complete foundations for hospitals, as well as the establishment of beds and contributions for heating and lighting, etc., were frequently made by lay persons.

As the hospitals increased in wealth and the religious orders grew lax in their discipline various abuses arose. Inefficient supervision by ecclesiastical authorities, too many attendants, too few beds, and imposition on the hospital by malingerers were among the evils which ultimately resulted in a loss of efficiency in these institutions. In spite of these drawbacks, however, says Virchow, "we have much to learn from the calumniated middle-ages, much that we with far more abundant means can emulate for the sake of God and man as well."

Pastoral medicine predominated up to the twelfth century and medical as well as surgical treatment was administered by monks and clerics. But with the rise of the university schools of medicine—Salerno, Montpellier, Bologna and Rome—and the development of such surgeons as Wm. Salicetto or Salicet, Henry Mondeville, Lanfranc and Guy de Chauliac during the thirteenth and fourteenth centuries, clerical medical practise began to wane.

It was deemed improper that a priest should shed blood and the church discouraged the practise of surgery by clerics as well as the practise of medicine for fees. Penalties for violating these precepts were laid down at the Council of Clermont (1130), Rheims (1131) and the Second and Fourth Lateran Councils (1134–1215).

The influence of the university-trained physician and surgeon on the hospital dates from this period. More and more we find lay practitioners called to attend hospital patients. In the sixteenth century we find the lay physician's connection with the Italian hospitals to be essentially the same as that in vogue at the present day. In 1524 Henry VIII. received a letter from the rector of the Hospital of Santa Maria Nuova in Florence, answering a request for information concerning the management of that hospital. From this letter we learn that three *adstantes*, or internes, attended patients and reported on their condition daily to six visiting physicians from the city. These six visiting physicians then outlined treatment and gave directions for the care of patients. Attached to the hospital was a dispensary for ambulatory cases. This was attended by an eminent surgeon and three assistants, all of whom gave their services without charge. Lallemand in his

"Histoire de la Charité"[11] gives a list of the many drugs used, and an outline of the pharmacist's duties.

Abuses in management and the civil and religious strife following the Reformation interrupted for a time the progress of the hospital movement. Revenues were cut off and hospital organizations disestablished, especially in England and Germany. It is true that attempts were made to carry on the work by parishes and municipalities, but with indifferent success.

Luther in his letters from Italy shows that he realized the importance of hospital work and he praised the Italian hospitals for their excellence. Meanwhile, a counter-reformation within the church organization was mindful of the hospital. Vives, the humanist of Bruges (1526), made a plea for a census of the inhabitants of cities, the regulation of vagrancy and hospital economy, whereby medical attendance was made more complete and the richer institutions were obliged to share their revenues with the poorer.[12] These salutary reforms were put into practise in Belgium and later were extended by Charles V. to his entire empire. In addition the Council of Trent passed rigid ordinances concerning hospital management and placed hospitals under episcopal supervision in order to prevent abuses and loose practises in administration. With these enactments improvement soon followed, and it is worthy of note that in the hospital at Milan, founded by St. Charles Borromeo, the rules sought to prevent malingering and obliged a strict accounting of its management.

In France the control of hospitals had passed to the king. Louis XIV. founded a special hospital at Paris for invalids, convalescents and incurables, as well as the great Hospital General for the poor. It was at this time that St. Vincent de Paul began his work and established the Sisters of Charity, a community destined to be famous for its work in camp and battlefield and to exert a tremendous influence on the development of nursing and the building and management of hospitals in all parts of the world. An increasing number of communities of women's nursing orders were formed from the sixteenth century onward until to-day they practically dominate this field of endeavor.

During the reign of Louis XVI. the Hôtel Dieu showed gross mismanagement and a frightful mortality. Sometimes as many as 5,000 patients were crowded there in utter neglect and abandonment. An eminent commission, including in its membership Tenon, Lavoisier and Laplace, was appointed by the king to formulate plans for remedying existing conditions. This board reported in 1788, recommending that certain wards be abandoned and that the pavilion system as exemplified in the hospital at Plymouth, England, be adopted. But the French

[11] See 7, II., 225.

[12] Vives, J. L., "De subventione pauperum," Bruges, 1526.

revolution intervened, and the needed improvements were not made until the nineteenth century.

When we consider the growth in population and wealth of nations and vaunted increase in knowledge, we can not look upon the eighteenth century as a period fruitful in hospital progress. Many new institutions were erected, it is true, but they were inadequate to the needs of the times in many respects. Among the most important establishments of this period were, in England: Westminster (1719), Guy's (1722), St. George's (1733); in Germany: the Charité in Berlin, established by Frederick II. (1710), and the Bamburg Hospital, by Bishop Van Erthral (1789); in Austria: the famous General Hospital, founded by Joseph II. (1784). Overcrowding, the prevalence of hospital gangrene and erysipelas, and the frightful mortality in many institutions made the very name hospital synonymous in the public mind with suffering and death. Yet, in spite of all this, it is from this very period that we see the development of the idea of the hospital as a necessary adjunct to medical and surgical teaching.

The history of American hospitals begins with the hospital erected by Cortez in the City of Mexico in 1524. It was remembered by the conqueror in his bequests, is still in existence as the Hospital Jesus Nazerino, and the ducal family descended from Cortez, the Dukes of Terranova y Monteleon, still exercise their prerogative of appointing its superintendents. A decade after its establishment came the Hospital of San Lazaro, accommodating 400 patients and, in 1540, the Royal Hospital, both in the City of Mexico.

Bancroft states that the law of 1541 ordered that hospitals be established in all Spanish and Indian towns. The Council of Lima (1583) made provision for the support of hospitals, and two distinct religious orders of men were founded in Mexico for hospital work.

In Canada, the Duchess of Aiguillon founded, in 1639, the Hotel Dieu, at Sillery, afterwards transferred to Quebec. The Hôtel Dieu, in Montreal, was founded in 1664; the General Hospital at Quebec in 1693.

The first hospital in the United States territory was erected about 1663 on Manhattan Island to care for ill soldiers and negroes of the East India Co. Early in the eighteenth century pest-houses for contagious diseases were established in various towns on the Atlantic coast. A permanent hospital for these ailments was built in Boston in 1717.

One of the petitioners for the incorporation of the Pennsylvania Hospital was Benjamin Franklin. The corner stone was laid in 1755, its charter having been obtained four years previously, but the structure was not completed until 1805.

The first privately endowed hospital established in the United States was the Charity, in New Orleans, founded about 1720 by a sailor named

Louis, afterwards an officer in the company of the Indies, who left a small fortune as a foundation. It was destroyed by fire in 1779 and the new Charity Hospital, now the City Hospital, was endowed in 1780. This is now one of the most important hospitals in America and receives over 8,000 patients annually.

The oldest hospital in New York City is the New York Hospital, founded in 1770 by private subscriptions. It was allowed £800 for a period of twenty years by the Municipal Assembly. The state legislature was more generous, allowing it £4,000 annually in 1795 and increasing it in 1796 to £5,000. Bellevue originated in the infirmary attached to the New York City Alms House. It was erected on its present site in 1811. Among the most important sectarian hospitals in New York are St. Vincent's, 1849, St. Luke's, 1850, and Mt. Sinai, 1852.

Fifty-six men of Boston in 1810 addressed a circular letter concerning the establishment in that city of a hospital for the poor. Jackson, Warren, and other medical lights of the day, worked out plans, and the institution, known as the Massachusetts General Hospital, was opened in 1821.

Of existing Baltimore institutions, St. Joseph's was established by the Sisters of St. Joseph in 1864; the Hebrew Hospital in 1867. The Johns Hopkins Hospital, chartered in 1867, was opened in 1889.

The District of Columbia had four hospitals during the cholera epidemic of 1832. The Washington Infirmary received congressional aid and it was proposed to enlarge it into a hospital, but it was burned during the Civil War. The Government Hospital for the Insane was established in 1852 to care for insane cases. Providence Hospital was established in 1861, largely through the efforts of Dr. Toner. Freedman's Hospital was opened in 1862 and Columbia Hospital in 1866. During the war sixty military hospitals were located in Washington and in the vicinity.

In the last half century the spread of hospitals throughout the world received a marvelous impetus. The rôle of bacteriology as applied to preventive medicine, surgery and therapeutics is one that must be accorded first place in advancing modern hospital efficiency. And in this connection the part played by Virchow's teaching of cellular pathology is a factor of much importance in its influence on medical thought reflected in hospital laboratory methods.

The Franco-Prussian and our own Civil War had much to do with directing men's attention to the problem of hospital construction and military surgery. Improved technique in nursing evolved the modern training school and created a distinctly new profession. Even before Lister's time, Florence Nightingale believed that soap and water and plenty of fresh air and sunlight would lessen mortality from hospital

gangrene. Pastor Fleidner, with his training school at Kaiserworth, and the Sisters of Charity in Paris and at the great General Hospital in Vienna, had practised, if they had not preached, this doctrine for a long time. It remained for the Crimean War and the dramatic demonstration of her doctrine by Miss Nightingale to convince the profession at large and the public. How it was accomplished is an oft-told tale. The later teaching of bacteriology in medical schools confirmed the claims for hospital cleanliness; hospital gangrene and epidemic erysipelas have disappeared.

Now is the golden age of the hospital; we need no statistics to convince us of this. Every American community of any size has not only a hospital, but a training school, and the old public distrust of the institution is on the wane with the improvement in methods and administration. To-day the patient approaches it with confidence instead of apprehension, with alacrity instead of with reluctance, and with the hope of life rather than with the fear of death.

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THE NEW OPTIMISM

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We may distinguish three stages in the development of optimism. There was first the old *a priori* optimism of St. Augustine and Leibniz. One hears no more of this now. You may prove from the good intentions of the Creator that this world *must be* the best possible one, but the whole argument rests upon presuppositions that have less weight than formerly. Browning, when he cries, "God's in his heaven, all's right with the world," fails likewise to convince us. We prefer to look about the world and in so doing we have little difficulty in seeing many things that are *not* right.

Then, there is a second kind of optimism which follows the opposite method, the inductive, and arrives at the conclusion that the world is good and beautiful and full of happiness. It may not, indeed, be the best possible world, but it is good and fair and perhaps growing better and fairer. This is the natural, buoyant, hopeful attitude of the normal, healthy individual who enjoys his food, his sleep, his work and his play and who delights to say with Ruskin,

> There really is no such thing as bad weather, only different kinds of good weather.

Of this class are the sane and helpful writings of Sir John Lubbock or the exultant songs of Walt Whitman, which refresh us with the optimism of youth, health and springtime. Dickens, likewise, compels us to a bright view of things by his contagious good cheer. Life can not be so very bad as long as there is a tavern near by with a pot of ale and a juicy joint.

Critics may call this the shallow optimism of the eupeptic man, but it is better and more natural than the dismal croakings of Schopenhauer or the songs of sorrow of Leopardi or James Thompson. The truth is, however, that this kind of optimism, as well as that first mentioned, implies a certain blindness to the actual evils and miseries of the world, or, perhaps more often, mere ignorance of them. Our faith in it is rudely shaken by a walk through the hospitals or prisons, the smell of anesthetics, a day's journey with a country doctor, a visit to the slums, a tour of the factories and mines, or a campaign in the regular army.

But now it can not escape the careful observer that there is at the opening of this century a third kind of optimism appearing, which we may call the new optimism. It might also be called dynamic, or practical, or psychological optimism. It concerns itself with no theoretical questions as to whether this world is the best possible one or not. It

has for its motto—The world is pretty good, and we will make it better.

In the first place, this view repudiates wholly the theory of the good old times and is able to show the fallacy upon which the theory depends. In the museum at Constantinople the writer saw an inscription upon an old stone. It was by King Naram Sin of Chaldea, 3800 years B.C., and it said,

> We have fallen upon evil times
> and the world has waxed very old and wicked.
> Politics are very corrupt.
> Children are no longer respectful to their parents.

This old and ever-recurring complaint does not depend upon any actual deterioration of the times, for the times are constantly growing better. It comes usually from older people whose outlook may be biased by subjective conditions due to decaying powers and by the tendency to regard all changes as changes for the worse, the only really good times being the bright days of our own youth. It is encouraged also by the fact that, since the springs of progress are in the human mind itself, it comes about that the present times are always below the standard set by our ideals and are regarded, therefore, as bad, being compared not really with the past, but with the ideals of our constructive imagination.

Careful historical comparison leads us to the result that there has been a rather steady progress forward in all things which conduce to human happiness. Anthropologists tell us that the health of the primitive man was nothing to boast of. He had little reserve force and slight power of sustained attention. His daily sufferings from hunger and thirst, from heat and cold, from dangers from wild animals and human enemies, from constant warfare, from loss of property by theft, from sickness and accident unalleviated by surgical care, and, worst of all, from never-ceasing fear of supernatural agencies, make his life seem in comparison with ours as one of extreme hardship and unhappiness.

In the palaces of the Homeric heroes, life was far too simple to seem to us very comfortable. Apparently they had commonly no nuts or fruits to eat, no green vegetables, no butter and usually no milk, no sugar, sweets or cakes, no boiled meats, no fish, no potatoes, no relishes, perhaps not even salt in the inland places, no tea, coffee, chocolate, or tobacco. Coarse bread with roasted meat, and sometimes cheese, honey, and wine, constituted the diet of the wealthy, and what the poor had to eat it is unsafe to say. The meat, which was their chief article of food, had to be killed just before it was eaten and right on the premises. This latter circumstance, together with their perpetual sacrifices of animals to the gods, must have made their homes most untidy, to say the least.

If, rather than the Homeric heroes, we consider the most highly civilized of the ancients, namely, the Athenians of the fourth and fifth centuries B.C., their daily life seems to us hardly more attractive.

Their comforts were few and their hardships many. Their food was like that of the Homeric Greeks. Their houses were gloomy and fragile and commonly shared by domestic animals. Their streets were unpaved and filthy. There was relatively little security either of life, property or reputation. Wars were almost incessant, bringing death, dishonor or slavery to both men and women. The reign of terror which prevailed throughout the cities of Greece during the long Peloponnesian war was too terrible for detailed description.

If we were to continue this study through the days of Rome, through the middle ages, through the centuries preceding our own, we should find that there has been a pretty steady growth in all the things which we usually regard as making life worth living. If by the good old times we mean the days of Queen Bess in England, the days of our Puritan forefathers, or the more recent years of our own fathers and grandfathers, history shows us that they were uninviting. There were more and harder work, fewer comforts, less cleanliness, coarser and less varied food, less security of person and property. The good old times are therefore a myth pure and simple. The Golden Age is not in the past, but in the present.

But, some one may say, a new list of evils has come to take the place of the old ones. It is true that material comforts were lacking in the other times, but people were more hardy then. They were more robust and wholesome and less sensitive to mere inconveniences. They lived, to be sure, on brick floors and wore homespun and went often to war, but they did not consider these things as hardships. They were brave and strong-shouldered and the very battles of life were a joy to them. Now we are weak-spirited and degenerate. Our young men are not so brave and our girls are not so modest. Our children, as Stanley Hall says,

> have limp and collapsed shoulders and chests, bilateral asymmetry, weak hearts, lungs and eyes, puny and bad voices, muddy or pallid complexions, tired ways, automatisms, dyspeptic stomachs, showing the lamentable and cumulative effects of long neglect of motor abilities.

We live in an overworked, serious and tense age. We have forgotten how to fight, to laugh, to eat, drink and be merry, but we have learned how to worry.

Furthermore, they continue, our manners and morals have deteriorated. Boodlers and bribers abound. A new bunch of grafters springs up for every one that is indicted. Jurors are fixed and voters bought and sold. Justice miscarries in our courts of law. Courts are dominated by shrewd attorneys more anxious for victory than for justice, urging delays and appeals based on mere technicalities. Then, there are the greedy trusts, the do-nothing congresses, the corruption of legislatures, jack-pot and bathroom politics, extravagance among the rich, increased frequency of divorce, smoking and drinking among women,

increased consumption of alcoholic drinks, adulteration of food, sentimentalism towards condemned criminals, yellow journals, comic supplements, and all the rest, not to speak of the wresting of lands from weak nations by strong ones, as in the case of France and Morocco, Italy and Turkey, England and the Transvaal, and the United States and Spain.

That these evils exist no optimist may deny, but that they offer any evidence that the present times are degenerate may be very seriously doubted. It may be doubted whether the young men of the olden times were any braver or had any broader shoulders, or that the girls were more modest or more virtuous. It may be doubted whether the children were of old any sounder or more robust. As regards each and all of the other indictments of the present times, it may well be doubted whether there has been any deterioration, on the whole; but rather it is probable that the farther back we go; the more weakness and deformity we shall find; the more graft, the more miscarriage of justice, the more dishonesty, the more drunkenness, the more wresting of lands from weak nations by strong ones.

The mere picturing of the evils of the present points to progress, for in times past not only were these evils present, but their presence was not much noticed. The more rare becomes crime the greater its interest for the headlines of our dailies. The muck rakers, if they had lived a few centuries ago, would have needed no rake to bring evils to the surface. No one, of course, would maintain that there has been a *uniform* progress or a *constant* decrease of evils, nor that all the sins of the present were found in the past, but on the whole the world has been getting better age by age and, sometimes, as at present, pretty fast.

But, it may be said, all this only proves that the world is getting better, not that it is intrinsically good. It might still be thoroughly bad and pessimism triumphant. With James Thompson we might still say:

> Speak not of comfort where no comfort is,
> Speak not at all: can words make foul things fair?
> Our life's a cheat, our death a black abyss.
> Hush, and be mute, envisaging despair.

As regards this question of the absolute goodness or evil of the world, the new optimism, as has already been intimated, does not greatly concern itself with it. It is rather disposed to see the good that there is and put shoulder to wheel and help it on. If, however, one were concerned with this question, it could no doubt be shown on sound psychological and biological principles that there must be a large balance of pleasure over pain wherever life forces are triumphant. But the *summum bonum* is not pleasure nor happiness, but, rather, abundance of life. Life is the key to the problem. So long as there is growth, movement, struggle, onward rush, conquest or noble defeat, there is little

pessimism. The fundamental things in our psychic life are not thought, deliberation, judgment, nor yet pleasure and pain, but rather, will, impulse, restless striving, love, aspiration, progress. It is only when these fundamental things are checked and one is forced to think and feel and examine one's feelings, that pessimism arises. Pleasures unearned are no guaranty of inward peace. As President Jordan says:

> There is no permanent state of happiness. Its joys must be won afresh with each new happy day. What we get we must earn, if it is to be really ours.

But now let us examine more carefully some of the aspects of the new optimism and some of the grounds upon which it rests. In this new philosophy of life, man is the central and determining figure. He can *make* the world good. This is a new thought in the history of optimism. We are not blind to the evils and the miseries of life, but we are conscious of a new inner force which can relieve them and redeem them. The old optimism said, Cheer up, for the world is good and beautiful. The new optimism says, Cheer up, for you can make the world good and beautiful. This view is a part of the powerful reaction which has been taking place for many years against the mechanical philosophy of life which prevailed in the latter part of the nineteenth century under the influence of Herbert Spencer and Charles Darwin. It came to be generally believed at that time that the world is merely a redistribution of matter and motion, that mechanical laws are sufficient to account for every phase of human life, including mental, moral and social phenomena, that at certain stages of organic evolution consciousness appears as a kind of by-product having no agency in the life drama itself, and that it is not necessary to take any account of it in explaining life, whether in its physiological, psychological or social aspects.

But now this disheartening philosophy is buffeted from every side, not more from the side of the psychologists and sociologists than from that of the biologists themselves. Grave doubts are cast upon the adequacy of natural selection to explain either the products or the direction of evolution, and it is now believed that there is some other determining factor which is spoken of now as consciousness, now as an initiatory psychic energy working towards definite ends, now as a vital impulse, a wellspring of progress or an original profound cosmic force. Whether consciousness itself be this original cosmic force, or whether, as some believe, it is a product of evolution, makes little difference in our problem, for human consciousness is here present in the world and it is a power which is changing not only the very face of the earth, but changing the direction of evolution itself. It would appear that consciousness has at this time reached a sort of adolescent or rapid growth stage in its development in which it has become conscious of its own powers, and this consciousness of itself increases tenfold its inherent force. We are, indeed, surrounded by mystery. Life is a puzzle and we may or

may not be able to solve it. But we find ourselves possessed of a certain power to mould our fate and to mould to a high degree the forms of nature about us. The world is plastic to the human will. In the last century, Hegel sounded this true note of human conquest, obscured as was his message by a fanciful metaphysic. Heine had the same thought when he spoke of "liberating the imprisoned energies of the human spirit." More recently, a whole group of writers, like Ibsen, for instance, have proclaimed their belief in a glad trust in nature and in human instincts. In America, William James, in his remarkable essay on "The Energies of Men" has shown the almost unlimited powers of accomplishment possessed by the human mind and the human body. In France, Bergson is showing to eager hearers from every part of the world that nature is a vital, not a mechanical, process, and that creation is something which we experience in ourselves in the freedom of action. Politically we see the same spirit exhibited in the twentieth century movements for freedom in Turkey, Portugal, Persia, Mexico, and even in China, where new and more liberal forms of government have been gained or demanded.

We may, then, say that the present epoch represents the emergence of consciousness as a determining and self-conscious factor into the progress of evolution, able in some measure to direct the evolutionary movement itself to the advantage of mankind and able to an indefinite extent to mould the forces of nature to the same end.

The directions in which this powerful conscious force is operating to further human well being are threefold.

First, it improves our material environment by the control and management of natural forces. In this direction tremendous advance is now being made in the invention of new machinery, in the discovery and utilization of new forms of energy, in improved methods of agriculture, in renewing impoverished soils by bacterial agencies, in creating new plants bearing useful fruits, in reclaiming arid lands by great systems of irrigation, in facilitating transportation by digging great canals, in making the air as well as the land and water viable, and in many other familiar ways.

Second, it is attempting with apparent success to improve the human constitution, both physical and mental, by intelligent use of the forces both of heredity and of environment. For instance, both the cause and the cure of tuberculosis have been discovered and we have hopes of eliminating entirely this cruel disease. Other diseases which in former times devastated whole regions have been practically conquered, while still others are now in process of control. Mortality has been lessened and longevity definitely increased, so that the population of nearly every country has risen, even where the birth rate has remained stationary or declined. Furthermore, consciousness itself has been made

a powerful instrument in directly enhancing human health and happiness in a group of movements of which the New Thought and Christian Science may be mentioned as examples. These movements have passed the experimental stage and are proving potent means in preventing and curing disease and promoting personal peace and harmony. Again, health leagues, committees on national vitality, scientific studies in nutrition, the warfare against insects and a host of such movements are all working towards increased happiness and increased health. But now it is proposed to go still farther in promoting human welfare by the direct application of the laws of heredity to the improvement of the race. Eugenics is the name of this new science and its aim is to teach us to be not merely well nourished and well nurtured, but also well born. Eugenics is defined by Galton as the study of agencies under social control that may improve or impair the racial qualities of future generations either physically or mentally. In eugenics we see consciousness arriving at sufficient maturity to control race culture. The possibilities of this new science are unlimited.

The third direction in which intelligence is working to further the welfare of man is in social and political relations. Here the advances are too many and too rapid for any one to catalogue. One might recall such gains as the abolition of slavery, religious toleration, freedom of speech, freedom of the press, freedom of opportunity, the limitation or abandonment of the death penalty, the humanizing of prisons, the restriction of child labor, and the substitution of wise charity and helpfulness for injurious almsgiving. The rights of labor are now recognized and the whole laboring class more justly remunerated and accorded a position of dignity and respect. The rights of the workingman, his welfare and his comfort are secured by workingmen's unions, protective insurance, factory laws, eight-hour laws, pure food laws, free schools, free public libraries and many other agencies, while the general spirit of social progress and social improvement is shown by lend-a-hand movements, worth-while movements, Christian Endeavor societies, civic art clubs, the conservation movement, movements for the promotion of civic righteousness, of the square deal, and of universal peace, neighborhood and social centers, social surveys, social settlements, and kindred efforts having in view the greater happiness of all the people. In the event of famine, earthquakes or disasters of any kind in any part of the world, abundant charity cheerfully given and economically administered is immediately forthcoming. Finally, we are seeing the beginning of the custom of distributing colossal private fortunes in establishing and maintaining free public libraries, great educational and humanitarian institutions, and institutions for medical research and scientific investigations.

In particular there are four aspects of modern life and society which are distinctly optimistic. First, the elimination of fear. Second,

the advance in the position of woman. Third, the gradually lessening frequency of war and its possible abolition. Fourth, the agitation against alcohol.

So free are we from fear that we do not realize the bondage of men in former times to both supernatural and political tyranny. Virgil represents Æneas as pulling up a little bush and finding clots of blood clinging to the roots, whereupon his terror was so great that his hair stood on end and his voice stuck in his throat. Fear is the greatest source of human suffering. Until comparatively recent times nature has been something unknown and the unknown has been a source of constant terror. It is believed to be full of supernatural and possibly hostile agencies. Devils and demons and indignant deities, an angry and jealous God, possible future and retributive punishments, earthquakes and eclipses, all have contributed to make the life of man miserable. This burden of woe has now been lifted. Another view of nature prevails. Man has cast off fear and finds himself master of nature and perhaps of all her forces, while in religion the gospel of love is casting out the dread monster of fear. But it is not alone fear of supernatural agencies that we have escaped, but also fear of political tyranny and of sudden political upheavals connected with despotic governments and social instability. Few of us appreciate the profound security that we now enjoy, security of life, property and reputation.

The wonderful advance in the domestic and social position of woman and her corresponding happiness sounds a strong optimistic note in the present. In Queen Elizabeth's time a married woman and all her possessions almost belonged to her husband, very much as did his horse. He could take away her property or her wages or even pound her with a stick. Gradually she has secured the right to her own property, to her own earnings, and to her own children, and is now rapidly gaining the right to hold office, the right to an equal voice in public affairs and the right to equality of industrial opportunity. Woman's suffrage, for instance, partial or complete, is a fact in large portions of the United States, in New Zealand, New South Wales, South and West Australia, Finland, Norway, Sweden, and other countries.

Another ground of optimism is found in the decreasing frequency of war. The cruelty of war, the physical and mental suffering, and the immediate and remote social consequences, all together represent only a part of its ultimate evils. In his little book on "The Human Harvest," David Starr Jordan has shown how war in the past has operated to produce human degeneracy by removing the best and strongest men and leaving at home the sick and the maimed, the lazy and inefficient, the slaves and the commonest laborers to become the fathers of the next generation. Now the conditions are different. Even in the event of a war in this country, the conditions are such that no serious depopulation could happen and in Europe wars are already too far

apart to have this effect. It is true that only a too sanguine optimism can see the immediate abolition of war, but it is equally beyond dispute that there are now powerful forces at work in the direction of universal peace.

Still another optimistic factor of the present is the crusade against alcohol. This is a determined and persistent opposition and in the end will eliminate its use. Hitherto the opposition has been largely sentimental and has been directed not so much against alcohol as against drunkenness. Recent studies in the psychology and physiology of alcohol lead us to believe that it is a race poison. It is the most deadly form of the downward or recalcitrant action of matter. So far back as history goes it has acted as one of the most serious impeding forces to the upward progress of the human spirit. It is in spite of alcohol that progress has continued from century to century. It is impossible to estimate the damage it has done to the human race. Its elimination will be a far more difficult problem than the abolition of war. The psychological cause of the universal desire for alcohol lies deeper than has been supposed, and it is only when this cause is understood that successful headway will be made against it. But it is undoubtedly true that alcohol will have to go. The emergence of woman into political and social affairs will add new vigor to the opposition to it and psychological, physiological and sociological studies will solve the problem of method.

But, now, it may be said, while these optimistic views of life and society are most cheering and suggestive, still they are in a certain way superficial and particularly so as regards the economic outlook for the future. There are deep-lying causes at work, it may be said, which look towards human degeneracy rather than towards human uplift. Our present prosperity is due very largely, for one thing, to the fact that there have been ever to the westward rich unoccupied lands to relieve the congestion of our population and react as an invigorating influence upon our eastern civilizations. These lands are now nearly all occupied, and henceforth, remembering Malthus's doctrine of the increase of population and the law of diminishing returns in agriculture, we may look for trouble. In the United States, it may be said, our present flamboyant prosperity is due to the fact that we are reveling in the wasteful use of a by no means inexhaustible supply of bituminous and anthracite coal, petroleum, natural gas, timber and soil fertility. The end of all these rich supplies can not be far away. If we could perchance find a substitute for our coal and timber, yet there is no way of supplying the combined nitrogen necessary to renew our soil when the present sources are exhausted. Again, in other directions, it is said, the social forces put into operation by man are Lilliputian and a single convulsion of nature may overthrow them all. Take, for instance, our war against contagious diseases. When we have eliminated them, we have destroyed nature's social scavengers and she will take a

terrible revenge. In former days, tuberculosis, typhus, typhoid fever and smallpox swept through the land, removing crowds of the unfit and those not immune to these diseases, leaving the sound, the hearty, and the immune to become the fathers and mothers of the next generation.

Perhaps the clearest statement of these views is found in an article on "Decadence and Civilization," by W. C. D. and Catherine D. Whetham in a recent number of *The Hibbert Journal.* These writers point out that in all our sympathetic care for the unfit we are sacrificing heredity to environment. "It is conceivable," they say, for instance, "that a wilderness of sanatoria may serve as easily to increase tubercular disease in the future as to diminish it in the present." As regards our warfare against alcohol, they continue, we are only laying up for ourselves future trouble. The races of southern Europe, where wine is abundant, have gradually become immune to alcohol, those families not able to use it moderately having perished, so that drunkenness, while formerly common in these countries, is now rare. Hence it is urged that, if by restrictive measures we make alcohol unattainable for the present, in the future a demoralizing wave of alcoholism will overcome all barriers, showing again that we are sacrificing heredity to present environment.

Again, still further and still worse, it is said, the emergence of woman into industrial and political life, while it will purify and ennoble society for the present, means race deterioration in the future. Say the same writers:

> Apparently, for a time we can shift a great part of the burdens of the country on to women, who can undersell their husbands and brothers and we probably effect thereby a distinct temporary improvement in our own generation, for a woman of better education and character can always be secured for a lower rate of pay; but we are devouring our one essential form of life capital, female humanity and the process must end in disaster.

A man may be a hard worker in industrial or political fields and at the same time the father of a robust and numerous family. On the contrary; a woman's "essential function is motherhood," and participation in industrial or political activity invariably interferes with this function.

> It is not a mere coincidence that the women whose names are best known and most distinguished for social, artistic and literary services were for the most part unmarried or childless, so that the special gifts which brought them fame died with them.

So much, then, for the voice of the pessimist. We must admit that there is force in these arguments and that some of the dangers referred to are real dangers, but the spirit of the new optimism affirms that all these difficulties as they arise will be successfully met by the unconquerable power of the human mind, as others have been met before. There may be, it is true, no more rich unoccupied lands to the westward, but scientific agriculture is showing that there are almost infinite unoccupied possibilities in the soil under our feet. Malthus's law of popu-

lation is a mere bugbear and agricultural science is turning the law of diminishing returns into a law of increasing returns. As regards the exhaustion of our forests and mines and the impoverishment of our soil, the conservation movement is already here to protect them. Our forests may be renewed as they are in other countries and substitutes may be found for our coal which will be as superior to it as the electric light is superior to the old candle or lamp. Few will be sorry to see the passing of the coal with its dirt and its smoke. As regards the exhaustion of the combined nitrogen of our soils, science even now is learning how to imprison the free nitrogen of the air.

In an article by W J McGee in *Science,* October 6, 1911, on the "Prospective Population of the United States," we have a painstaking study of this subject, based on all kinds of data, including not only the observed decrease in human productivity, but also the relation of our natural resources to the increase of population. He finds the only real limitation of our natural resources to be in the water supply, and taking this fully into account, he estimates the population of the United States to be doubled in 1950, trebled in 1980, quadrupled in 2010, and so on to the year 2210, when we shall be supporting over eleven times our present population, or 1,017,000,000 people. His view is wholly optimistic, showing how movements already initiated are likely to overcome great apparent evils.

As regards the action of tuberculosis and other diseases of this class in purifying society by removing the unfit, it may be answered without hesitation that sanitary science can provide methods of purification far superior to these filthy diseases. An unsanitary medieval city might perhaps need dogs as scavengers. A well-kept modern city needs none such. So in regard to any possible racial deterioration as the result of the participation of mothers in industrial and political occupations, it is the business of society to consider just as much the conservation of human health and human vitality as the conservation of our forests and our soils. It is by no means impossible that society in the future will find means of preventing the production of the unfit and providing for the production of the best. The present movement in advancing the position of woman may go farther than equality of rights. It may give to the future mothers of the nation superior rights and superior privileges. The notion, however, that work and motherhood are incompatible has no foundation in experience. Small families and weak children are more often found among the idle and luxurious than among the workers.

The fact is that pessimism finds its explanation not in objective, but in subjective conditions. The psychological grounds of pessimism are not obscure. It springs usually from one of three sources. The first of these is lowered vitality. Optimism is the natural and necessary accompaniment of health. It flows from it as naturally as light from the sun. It is just the mental reflex of that normal physical activity

which belongs to the healthy body. Pessimism is the mental reflex of disturbed function, sometimes of the nerves, commonly of the liver or kidneys.

Then, secondly, pessimism comes in part from the over-seriousness and over-sensitiveness of the age, the incidental accompaniment of what we have called the adolescent stage in the development of human consciousness. The childhood of the race has past. We have become self-conscious, reflective, conscientious, a little careworn. The boyish, rollicking, happy-go-lucky abandon and exuberance of spirit exhibited in the writings of Shakespeare's times are absent now. In those days social conditions were relatively bad and comforts few, yet they did not care so much. They did not take life too seriously. They ate, drank, laughed, and died when their time came. Now we worry more. Writers like Tolstoi take life very seriously. Conditions in Russia are no doubt bad, but they are not worse than they have been and they are not sufficiently bad to fill a man's soul with such bottomless gloom as they did the soul of Tolstoi. His was an extreme case of the over-sensitiveness and over-conscientiousness of the age. He was unhappy because he had bread when others hungered, a condition which in former times has usually been the occasion of rejoicing. Our own sins and the sins of our legislators, our political leaders, and our masters of capital lie like an incubus on our spirits.

Thus we have already anticipated the third ground of pessimism. It is that we compare our present condition not with the past but with the ideal future, or rather with an ideal state which consciousness itself creates. Our physical condition, could it have been foreseen by Francis Bacon, would have seemed a veritable paradise. But we are not happy. Our workmen have better wages and fewer hardships than ever workmen had before, yet they are not satisfied. The New Atlantis is ever in the future. Thus, we come back to the position already indicated, that human consciousness is a wellspring of progress. It creates ideals and it is with these ideals that we compare our present attainments and pronounce them imperfect. This is what makes progress possible. It is the eternal unrest, the eternal aspiration of the human mind, which is never satisfied with the good, but urges us ever forward to something better.

We often hear reference made to "political unrest," as if it were some inherent social defect, a mere petulant, purposeless fault finding. But it is not a defect. It is the voice of progress proclaiming its discontent with the present and demanding improvement; not an idle but a rational discontent, recognizing the real evils of the times and perceiving more or less clearly the direction of the upward way. What, therefore, appears as pessimism is really the ground of the highest optimism. There is no static happiness, no happiness of mere content and satisfaction. What we require is growth, movement, struggle, aspiration, conquest.

WELFARE AND THE NEW ECONOMICS

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ECONOMIC thought is undergoing a profound and rapid transformation. Linked, as it must ever be, with the problems of government, economics has been drawn into the maelstrom of progressivism which has gripped the western world. Vainly do the classicists protest. Futility grips the throats of the doctrinaires. Economic science is being wrenched from its eighteenth-century setting and thrown bodily into the arena of twentieth-century discussion. How sound is this tendency? With what disquietude or satisfaction should men view the efforts of economists to take their places "on the firing line of progress"?

Society was ruled during the middle ages by arbitrary laws, enacted by the church, or by the state, acting (theoretically) for the church. The light of the semi-democratic civilization of Greece and Rome had faded from the political horizon. Despotism, the patron saint of the time, reigned supreme with fate, her next of kin.

Here and there a bold spirit arose, contending with authority, questioning theological dogma, and calling men to thought and freedom. Cells and gibbets harbored many such. Above them, the bulwarks of social tradition loomed stolidly, proclaiming abroad the noisome doctrine that, while a true believer might slay twenty Mohammedans in the name of Jesus, he might not think one original thought in the name of truth.

Yet the light broke. From questioning the infallibility of a corrupt and dissolute church, men turned to question the infallibility of the Scripture. They would at least read for themselves. So theological dogma was thrust aside here and there, by the braver hearts who began to ask of all things:

1. What is it?
2. Why is it?
3. How can we employ it for our advantage?

Similar questions had arisen in classical days, but the age of Scripture had overshadowed them. Now they were asked again, with redoubled vigor.

Gradually the answers were formulated. The first question resulted in classification, which is the foundation of constructive thought. The question "Why?" gave rise to evolutionary science. The world,

demanding fact as well as faith, was replacing theological dogma by scientific deduction.

Although it was freed from theological dogma, the progressive thought of the seventeenth and eighteen centuries was still dominated by the idea that laws of some kind were a human necessity. The social atmosphere still tingled with the spirit of past despotism. Hence, without a protest, men passed from the dominion of theological to the dominion of natural law. Even the ablest thinkers sought for principles which, like Newton's law of gravitation, would underlie and control all phenomena. The protest, "back to nature" was merely a demand that the world leap from the frying pan of theological absolution into the fire of nature-tyranny. Yet the thought of the eighteenth century teems with this demand. The Physiocrats voiced it; the natural theologians preached it; Rousseau popularized it. Its logical flower was the French Revolution, which was a blind effort to pour the new wine of emancipated thought into the old bottles of political pedantry. In the process much wine was lost. "Natural law" dogma bound the thought of eighteenth-century thinkers in exactly the same way that the "divine right" dogma had bound the thought of their ancestors.

Economics was born in the eighteenth century—born of natural theology and physiocratic philosophy. Hereditarily, economics suffered from inbreeding. Environmentally, it was hedged in by the narrowest of narrow concepts—that of subjection to "higher powers."

Was economics to become a science? Adam Smith and his contemporaries hoped that it was. How well marked, then, was the path! All sciences were founded on natural laws. If economics was to be raised into the hierarchy of sciences, a greater natural law must be found which would explain economic phenomena. The economists, therefore, applied the tests of science to their doctrines in order to establish their scientific nature. To the question, "What is it?" they replied, "A science of wealth." To the question, "Why is it?" they answered, "because of intelligent self-interst," "the law of supply and demand," "competition," and the like. The third question they did not ask because the eighteenth century accepted and obeyed nature's laws instead of trying to utilize them for human advantage.

Nevertheless, the third question must be answered. Of all things men will ultimately ask, "How can we employ these for our advantage?" The basis of the answer was laid in the sixteenth and seventeenth centuries, when free thought had largely escaped from theological dogma; when knowledge had ceased to be the right of the few and had become the privilege of all. In the eighteenth century the question was asked of the government. Men challenged the divine right of kings, and on both sides of the Atlantic democracy replaced monarchy.

During the nineteenth century experimental science asked the same question of natural law; established the power of human thought; forged the tools with which the work must be done; and bent immutable nature to the service of man through applied science. Thus knowledge, government and natural phenomena have been turned to human service. The twentieth century voices a demand that economics undergo the same process of transformation from a science which serves laws, to a science which serves society.

The claim of economics for conversion to social service is a double one. On the one hand, science has demonstrated that all so-called laws may be employed to serve men, or else, if their influence is harmful, counteracted and offset. Gravitation has ceased to be an enemy; the lightning holds few terrors; the waterfall is harnessed; the plague stayed; the desert blooms; time and space have lost their vastness; men have triumphed everywhere through the mastery of human thought. Whatever laws economics may depend upon are no more changeless than these overwhelmed laws of nature.

On the other hand, men have learned that the laws of economics differ from the laws of natural science in that the whole subject matter of economics is man made—the product of human activity. The laws of physics and chemistry are laws of a universe, which man had no part in creating. Economics, however, is the result of a man's creative energy, for man has made the economic world. Interest, wages, competition, monopoly, capital and private property are all the products of his ingenuity. The concept of law presupposes a law giver. Who gave the laws of the universe? We answer, God. Who made the laws of political economy? Man, because he constructed the economic system to which alone the laws of economics apply.

We are no more subject to the laws of economics than our ancestors were subject to the law of military tactics; than we are subject to the laws of education; or than our descendants will be subject to the laws of the sanitary science which we are creating. There are formulas of thought called "laws" in all sciences, but Napoleon overthrew and remade the laws of military tactics; Froebel restated the laws of education; and Pasteur created the science of sanitation. There is an economic law giver—man, who can unmake or remake that which he has made.

The laws of economics are in truth mere incidents in social evolution. Queen Elizabeth and her successors granted trade monopolies to favorites. The eighteenth-century economists enunciated the laws of competition and equal freedom as the great law of economics—the cure-all for economic woes, and lo, the Standard Oil Company, employing the law of competition as its most fearful weapon, has created a monopoly as complete as any ever granted by an absolute monarch. If we

lived under a barter economy, we should work out its laws. We broke away from the domestic system of industry when inventors made possible the factory system. The economic world is still in the making. Men are doing the work.

So long as men regard the laws of political economy as immutable, so long will they be in the grip of the powers which these laws express. It is in vain that Karl Marx argues regarding economic determinism; it is futile for Henry George to "seek the law which associates poverty with progress"; the future is hopeless so long as men believe that political economy is "as exact a science as geometry." Under the domination of economic law, the exploiter will continue to exploit, and the exploited to suffer. Not until men realize that they are the creators and arbiters of economic laws will economic laws subserve human welfare. The dawning lies beyond the fetish of economic determinism; the hope for the future rests upon man's ability to make of political economy an eclectic philosophy.

The economists in the past have asked "What?" and "Why?" of economic phenomena. The time has now come when they must face the third question and discover how economics may be made to serve mankind. Progress in other sciences has led plain men to question the validity of the fatalistic philosophy of Ricardo; the gloomy forebodings of Malthus; and the necessity for poverty, overwork, untimely death and the devastations wrought by the brutal hand of cut-throat competition. The discovery that opportunity largely shapes the life of the average man, determining whether he shall be happy or miserable, has led to an insistence that the economists part company with the ominous pictures of an overpopulated, starving world, prostrate before the throne of "competition," "psychic value," "individual initiative," "private property," or some other pseudo god, and tell men in simple, straightforward language how they may combine, reshape or overcome the laws and utilize them as a blessing instead of enduring them as a burden and a curse. The day has dawned when economists must explain that welfare must be put before wealth; that the iron law of wages may be shattered by a minimum-wage law; that universal overpopulation is being prevented by a universal restriction in the birth rate; that overwork, untimely death and a host of other economic maladjustments will disappear before an educated, legislating public opinion; and that combination and cooperation may be employed to silence forever the savage demands of unrestricted competition. In short, the economists, if they are to justify their existence, must provide a theory which will enable the average man, by cooperating with his fellows, to bear more easily the burden and heat of the day.

How shall this be? What relief may economics—"the dismal science"—afford? Perhaps the matter can best be stated in an analogy

suggested by Ruskin. Suppose that five men were to take a tract of a thousand acres for the purpose of running a general farm. Learned in the art of scientific agriculture, these men provide the necessary tools, equipment, fertilizers and seeds, prepare the ground, sow the crops, harvest the grain, potatoes, fruit and vegetables, and take them to market. Where they find their land too wet, they drain it; if, perchance, the tract is too dry, they irrigate; and if a test shows that a certain field needs lime, they promptly apply lime. These men are farming the land. They do not wait for the land to produce a living for them, but instead, they use the land in every conceivable way.

Suppose that, instead of fertilizing, irrigating and draining, these men upon discovering that one plot was very fertile, farmed only that plot, leaving the less fertile parts of the farm untilled; suppose that, when water stood in a field, they invoked the aid of physics and mathematics, ascertained that this field was low, and therefore bound to be wet; suppose that they abandoned a hill plot which would not raise tobacco without even attempting to ascertain whether it would grow buckwheat; suppose that after venturing timidly to try a few minor experiments, these men, discouraged and forlorn, should assemble around a stone, and, raising their hands to the sky, should beseech some higher power to make water run up-hill or tobacco grow on buckwheat land. Or, instead of praying, imagine their hopeless, hang-dog air as they gazed dejectedly over their thousand acres, exclaiming: "Alas, the law of gravitation makes our low land wet; tobacco will not grow on the highland; yonder field contains no lime for our clover crop; and even the cattle in the hill pasture suffer from lack of water."

What a picture! You sneer, contemptuously. "What sane man would talk so?" you demand. "The illustration approaches the ridiculous. Beseech a higher power? Bemoan the law of gravitation? Fiddlesticks! Irrigate, drain, lime, water, fertilize, and the land will bring forth in abundance."

True, true, but listen! Ninety million people, some of them intelligent men and women, living in one of the most fertile regions of the whole earth, possessed of boundless natural resources, of knowledge and of energy, have suffered for a century from devastating industrial depressions; have watched little children work their fingers raw in the coal breakers; have witnessed an exploitation of women that has required two hundred thousand of them to sell their bodies; have tolerated sodden misery, poverty, vice, criminality; have permitted one small group in the community to possess itself of the natural resources on which all depend, and to exact a monopoly price, from all, for the use of those resources; and now, after generations of this gruesome motion picture, these sane, strong men and women raise their hands to a higher power, or slink dejectedly into their caricature homes, making

scarcely an effort to throttle their taskmasters—hunger and emulation—or to stay the hand of the grim reaper who annually sends seven hundred thousand of them to premature graves.

Irrigate! Drain! Lime! Fertilize! Aye, farmer, do these things, and you will reap a plenteous harvest. You possess the knowledge and the tools—then bend enthusiastically to your task.

Educate! Legislate! Reorganize! Adjust! Aye, citizen, do these things and you will gain a satisfying livelihood. You possess the knowledge, the wealth, the tools—then bend enthusiastically to your task.

The time has passed when the man with the hoe, "bowed with the weight of centuries," "gazes on the ground," toiling that he may pay an eternal tribute to the feudal overlord. To-day he looks the future full in the face, and, with the faith of a freeman, applies natural science to the solution of the heretofore inscrutable agriculture problems. The time is coming when the man at the machine—striving, frantically hurrying through the long reaches of the ten-hour day—that he may obtain the wherewithal to buy for him and his bread, books, shoes and pleasure trips—servile to economic laws which he can neither understand nor master—will look the present system of industrial society full in the face, and with the faith of an emancipated soul will consign its laws to the devil and use the knowledge and the tools which the past has given him, to provide himself with the means whereby he may live.

Political economy is not a science founded on eternal principles, but a philosophy of livelihood. Its aim is not to astound us with its mathematical premises, or to frighten us with its threats of world disaster, but to outline a method by which men may raise the heavy yoke of traditional servitude and secure a more satisfactory living.

SCHOLARSHIP AND THE STATE

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FROM time to time articles appear from the press and more frequently still words are passed from person to person, which indicate that a great many citizens of our American states believe that scholarship exists only for the pleasure and profit of those who seek it. It is believed that this attitude arises more from lack of information and thought on the subject than it does from the general bad practises of those who proclaim scholarship. Consequently this paper shall purpose to set forth one simple, and it is believed irrefutable, argument for state support to scholarship.

The state may be regarded as an expression of the continuity of human life, and we may therefore postulate that it is its first duty to perpetuate itself. In spite of the fact that science shows that it is highly improbable that any state can live forever, it is nevertheless generally agreed that if the state so conducts itself as though it intended to live forever, it will live the longest and be the happiest while it does live.

Unfortunately there are many people who seem to think that the only duty of a state is to look after the welfare of the present generation. They somewhat seriously ask, "What has posterity ever done for us?" Perhaps we may compromise with these, for the sake of our discussion, on the basis that neither the present nor the future welfare of the community can exist independent of the other. In general there is a lack of far-sightedness among American citizens. H. G. Wells calls it, "state blindness." He says: "The typical American has no sense of the state." President Vincent, however, believes that the state is coming to stand for a common life which seeks to gain ever higher levels of efficiency, justice, happiness and solidarity. Ambassador Bryce, who seems to know us better than we know ourselves, declares:

> The state is not to them (Americans), as to Germans, or Frenchmen, and even some English thinkers, an ideal moral power charged with the duty of forming the characters and guiding the lives of its subjects.

I wish to present in this paper an ideal for the permanent and increasing betterment of the state and to suggest means for carrying out the ideal, for, as Arnold Toynbee once said:

> Enthusiasm can only be aroused by two things, first an ideal which takes the imagination by storm and second a definite intelligible plan for carrying the ideal into practise.

The future welfare of the state depends on economic and moral conditions. If the natural resources are used up and new resources are not discovered to supplant them, if the soil is worn out, the coal and other minerals are used up and wasted, the rivers are allowed to fill up, then organized human life will be almost impossible. On the other hand, if all the natural wealth were preserved and the coming generations should not be taught so as to appreciate proper moral standards, then obviously the natural wealth would be of no use.

The postulates naturally lead us to declare that it is the state's duty to investigate how it may best safeguard its future, and also to take what action best judgment may dictate. The first question that arises is whence is this best judgment to come. Plato's ideal state was to be provided with seers or wise men selected and trained according to the judgment of the wise men of the previous generation. But this idea is fundamentally at variance with the ideals and practises of our democracy. The people of the states of our time do not believe that any wise man, or any set of wise men, have the ability or the right to know beforehand what youths will when matured fully be best suited to direct the welfare of a single generation, much less the ability to select the future men of best judgment.

The idea is pretty well grounded in the American states, particularly in the west and the middle west, that the state should with all its power endeavor to see that every youth within its bounds should have equal opportunities to make the most with his native ability. No human power can distinguish a Lincoln before he has well matured. It is the privilege of the state, yes, it is even its duty, to see that every person shall do as much as possible, leaving it in a large measure to the individual to know what he should do. We must therefore admit that it is the duty of the state to offer educational assistance to all who will take it, and that this education must usually partake of two ideals which are apparently diametrically opposite. The ideal education will fit the individual to be proficient in some useful line of activity, and at the same time give him such a general education that he may be morally sound. The first is the element of the professional education and the second is the element of the liberal education. Excellence in the first requires, providing the number of individuals are properly distributed, essentially a narrow life, and gives a high efficiency with large immediate rewards both to the individual and to the state. Excellence in the latter gives a broad view of the functions of the individual and of the relative values of the various activities. So long as we maintain our democratic habits and insist on selecting our wise men fully developed from among the masses, the state should insist, as far as its wealth and its power will permit, that all the individuals should have a liberal education. No method of reasoning or no experience of the past can show

that the state can wisely permanently entrust the education of the individuals to any group of men or any group of interests. Logically this could only happen when the group interests become identical to the interests of the state.

The danger of permitting commercial interests to provide all education would be probably as great as the danger of extending that privilege to religious denominations. The commercial interests are not fearing a dearth in their supply of presidents and directors of their companies. These high offices can willingly be handed over to the friends and sons of the controlling millionaires. What they do want is trained labor. They want the stenographers who can give the greatest numbers of words for their money. They want draughtsmen who can give the most and best designs for a particular machine. They want in every case experts who can give the best judgment on a particular line of goods. It is of less than secondary interest to the factory owner, whether any of his employees can vote intelligently and conscientiously, or it may be stated more broadly that he little cares whether the men of his corporation are morally sound. Although it may seem a little inconsistent, he does want men who will not rob his cash register, or purposely endanger the owner's life. Consequently there are organized commercial interests at work in this country trying to get the universities to give the professional students a more narrow education than they now receive. They call it a more efficient education. They insist that it is scandalous that an engineering graduate is not worth more than twenty cents an hour to start, forgetting that the ideals and practises of society should be raised to a higher level by the work of the university. The late Mr. Crane recently, in criticizing the professional education of the University of Illinois, stated that the cost of training was out of all proportion to the product. He figured that the really successful electrical engineer cost the state upwards of $18,000. My reply is that the electrical engineering profession to-day stands as a monument to good investment of money and energy in pure and applied science, and this without calling especial attention to the betterment of society by the better class of engineers.

On the other hand, if the church controlled education, the training would perhaps be so idealistic that there might be considerable doubt if any of the practical needs of the professions would be met. A really successful electrical engineer would not be produced at any cost. Church education, naturally conservative, would be entirely inadequate for the needs of our changing democracy, even if it should try to eliminate creed. The conclusion is that even if the preachers, the doctors, the dentists, or the engineers would furnish all the money to educate their kind, the state can not afford to risk giving them this privilege.

The plea is that the state university, as the only fit organ of the

state, must first of all not merely consent to train men for the professions that serve the masses, but that it must demand this right. Of course we are assuming that the state is not a poverty-stricken one, and that it is not fighting for a bare existence. Secondly, the state's university must insist on giving its students a broad education. By this is meant that all students should not only be trained toward a professional career, but that they should also have the elements of a liberal education. They should by all means appreciate the value of scholarship in most lines of endeavor. President James says:

> I believe that the proper way to train a man or woman who is going to practise one of these learned professions, so far as a school can train him, is to prepare him for independent work in the sciences underlying his profession.

I understand that to mean that a graduate in electrical engineering should be prepared to carry on research work in physics.

And what is scholarship? It is the discovering of new knowledge and the proper dissemination of this knowledge. The discovery is the most important because it is the basis and the inspiration. There can be no permanent scholarship without research. I believe that it is more difficult to keep a semblance of scholarship alive without research, than it is to keep religion alive without spiritual leadership.

In how far is it wise to expect the state to foster research? To answer this question we may first inquire into the economic importance of investigation. A few years ago the members of the agricultural college of the University of Illinois went before the legislature and showed that they could make it possible to increase the yield of corn in Illinois by one bushel per acre, and that thereby they would repay all the money to run their college, if they did nothing else. This argument was so plain that the legislators could understand it and they gave practically all the money asked for. The money showed such good results in such a short time, that the engineering departments were then emboldened to lobby before the legislature, trying to show that money expended on research in engineering would be of great benefit to the state. They said that in ceramics they would investigate all the clays of the state to find building materials to replace the fast vanishing supplies of wood and iron. In mechanics they would investigate reinforced concrete so as to make it possible to construct buildings that would last for generations at a small cost. The legislature could understand this argument and so it gave bounteously to the engineering experiment station. The experiments in this station attracted attention over the whole world. The president then asked for an unheard-of lump sum of money for the graduate college in arts and sciences, merely to further knowledge in those subjects which were not of immediate value to the masses. This also was granted. The result of all this movement was that at the last legislature the University of Illinois was granted a sum of money in

excess of any one sum ever before in the history of the world by a single legislative enactment. This was in Lorimer's state and in Lorimer's time, strange as it might seem.

According to Dr. W. R. Whitney, in charge of the General Electric Company research laboratories, the advances in incandescent lighting alone in this country in the last ten years represent a saving of $240,000,000 a year or nearly a million dollars a day. He also calls attention to the fact that as a result of investigations with the mercury arc, his company has already had a sale of over a million dollars extra. There are a great many concerns in this country spending over a hundred thousand dollars annually on research. And why do they do it? Because it pays the company. Dr. Whitney believes that the advances of Germany over the other countries is largely traceable to their apparent overproduction of research men by well-fitted universities and technical schools. My argument is very simple. If an electrical concern that must at all odds pay dividends to the present generation, can afford to pay over a hundred thousand dollars annually for research, how much can the state afford to pay for research in pure science, in physics, in mathematics and chemistry, which will bė absolutely essential to radical progress a century hence. The law governing the relation between visible radiation and temperature has been the guiding principle to most of the hundreds of thousands of dollars spent by present day commercial firms for more efficient lighting. New laws by the physicists of to-day will set new guiding principles for the millions of the future. The laws of induction as discovered in pure physics had to precede the most wonderful development in electrical engineering that this age or any age has witnessed in any line. My whole argument can be summed up here briefly as follows. Knowledge is the source of all power. If the state would get more power it must gain more knowledge. No wonder President E. J. James has been led to exclaim,

> Why, research is the life of the state university! It (research) is fundamental to it! Without that it could not be a university in any proper sense of the term. If its professors are not doing this, they are not qualified to give the training which we have in mind for the youth of the state who go there. So that research, investigation, is a fundamental quality of the state university, which is going to do for the people of the state the service which they have a right to expect.

Perhaps the moral status of the state is as important as food and shelter. I believe that the moral condition can be improved only by a further acquisition of the facts as to what promotes and what hinders well-being. Thus all knowledge improves moral conditions. The intelligent investigation of the results of alcoholic drinks is doing more toward driving out the drink habit than all the hatchets. The intelligent and unbiased investigation of the moral status of small towns

can not help but improve conditions. The man whose researches have shown him definitely what can be done to improve morals will always mark progress. The man who can point out just how the practise of the simple virtues of honesty and faith can better any particular conditions is certain to better social conditions.

It may be mentioned that all research in the right spirit has a moral value, which, however, it is difficult to evaluate in simple units. Any man who is striving to extend the bounds of human knowledge is thus far a source of inspiration to all who know him, and a lesson in faith and hope to those who know of him. Particularly in a university the teachings of a man of research are those that are most likely to inspire the spirit of wonder and high ideals among the students. It has hardly been the province of this paper to point out how the installation of the proper ideals, free from tawdry sentiment, among university students, permeates the whole society of the state.

Why must not a state entrust the seeking after knowledge to institutions outside the state? One university professor once said that it was useless for a state to try to build up a respectable graduate school near Chicago University. The inference was that the state could well let Mr. Rockefeller's millions seek after new knowledge and then help itself. Of course it might, but this attitude when looked into carefully is ridiculous. It is just as bad as for a citizen to depend on his generous neighbor's parlors to entertain his company. If a state would be a parasite and depend upon forces outside itself to develop new knowledge, then by the laws of nature it must take the chances of a parasite. But I believe that with a healthy, wealthy and vigorous body of people, state pride will forever demand that the state shall do its share toward productive scholarship.

ADAM SEDGWICK,

late professor of zoology at Cambridge and London, by whose death at the age of fifty-seven years science has suffered a serious loss.

THE PROGRESS OF SCIENCE

THE NUMBER OF SCIENTIFIC MEN IN THE WORLD

The second edition of the international "Who's Who in Science" (edited by H. H. Stephenson, London, 1913) gives a classified index, from which can be counted up the number of scientific men in different countries and in different sciences. The compilation favors Great Britain in the first instance and the United States in the second, and is not very critical. It gives, however, some idea of the relative numbers of scientific men in other than English-speaking countries. The United States is given first place in the possession of scientific men of the degree of distinction proposed for admission to the book, the figures for leading nations being as follows: United States, 1,678; Great Britain, 1,472; German Empire, 1,280; France, 423; Austria-Hungary, 348; Italy, 215; Switzerland, 214; Holland, 155; Canada, 146; Sweden, 109; Russia, 97; Denmark, 93; Belgium, 90; Norway, 88. The German Empire has thus about three times as many scientific men as France, which nation is now but little superior to Austria-Hungary, or the three Scandinavian nations. Italy and Switzerland have each about one half as many scientific men as France. Sweden, Russia, Denmark, Belgium and Norway have each about a quarter as many.

About one half of our scientific men hold the doctorate of philosophy from American universities and about three fourths of those receiving this degree continue to do scientific work. According to the compilation printed annually in *Science*, the average number of degrees conferred in the natural and exact sciences from 1898 to 1907 was 124; from 1908 to 1912 it increased to 212. As the number of scientific men added each year is about 50 per cent. above those who receive this degree, the total number added to the ranks of scientific men in this country during the past fifteen years would be about 3,500. The number of degrees of doctor of philosophy given in the sciences by the 21 German universities to Germans in 1909–10 was 564, which probably about represents the increase in the number of scientific men. It follows that at present we are producing about half as many scientific men as Germany; twenty years ago it was in the neighborhood of one fourth as many.

If we make the assumption that the numbers of scientific men entered in the international "Who's Who in Science" for the continental nations should be increased fourfold to correspond with the entries for the United States and the United Kingdom and that there are 6,000 scientific men in the United States, the numbers for the different nations would be approximately: Germany, 18,000; France, 6,000; United States, 6,000; Great Britain, 5,000; Austria, 5,000; Italy, 3,000; Switzerland, 3,000; Holland, 2,000; Sweden, Russia, Denmark, Belgium and Norway, 1,500; Canada, Spain, Portugal, 500; Bulgaria, Roumania, 150; Servia, Greece, 25. For the other continents the figures would be roughly: Asia, 2,000; Central and South America, 500; Australia, 500; Africa, 300. The number of men now living who have made contributions to the advancement of science is consequently in the neighborhood of 60,000, of whom about one tenth live in the United States. The number of scientific men per million population in 1860 (the approximate average date of their birth) would be for the several countries: Switzerland, 1,200;

Denmark, 938; Norway, 938; Holland, 606; Germany, 472; Sweden, 395; Belgium, 320; United States, 191; Great Britain and Ireland, 172; France, 163; Italy, 120; Austria-Hungary, 73; Russia, 22. The number for Massachusetts is 654, placing that state above Holland. As De Candolle has shown, the supremacy of Switzerland has been maintained for 200 years. He gives political and social causes which he holds would account for it. These also apply in large measure to Denmark, Norway and Holland.

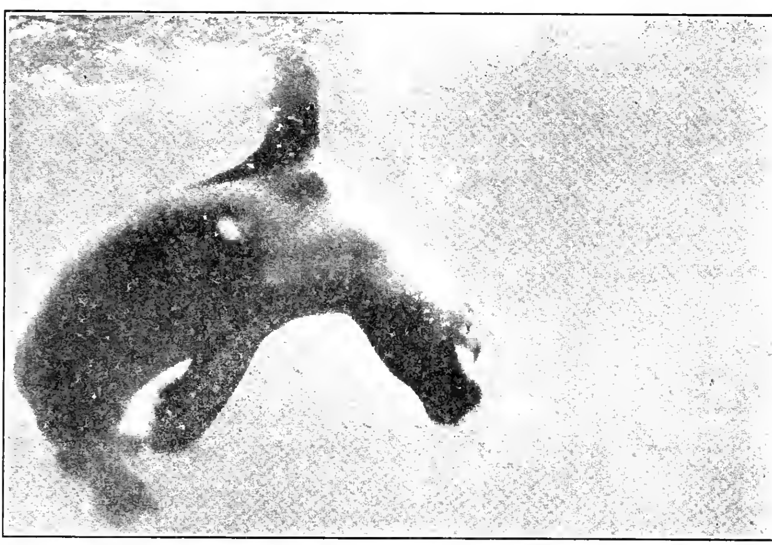
THE SCIENTIFIC CAREER IN THE UNITED STATES

The number of scientific men of distinction would tend to be in proportion to the total number of scientific men a generation ago rather than at present, and the United States can not expect to have nearly one tenth of the eminent scientific men of the world. Professor Pickering found (The Popular Science Monthly, October, 1908, and January, 1909) that of the 87 scientific men who were members of at least two foreign academies, six were Americans, as compared with 17 from Prussia, 13 from England and 12 from France. In so far as our scientific production is so measured, the reference is to a generation ago when our universities were only beginning to develop and research work was only beginning to be appreciated. It is a striking fact that of the six distinguished Americans, three are astronomers; and astronomy is the only science in which thirty years ago the facilities for research work in this country were equal to those of the leading European nations. Of the remaining three, two have not been engaged in teaching, and the third has been practically freed from teaching for his research work.

It is not possible for men to earn their livings by scientific research. Like other work for the benefit of society as a whole, and unlike business or professional service which can be sold to individuals, it must be rewarded by society. In the past reputation, social recognition, titles, prizes degrees, membership in academies and the like have been used as rewards, but these form a fiat currency which is now debased and scarcely passes in this country. It presupposes that the scientific man has independent means of support, and the group from which he can come is comparatively small. The method has succeeded in Great Britain, but in our democracy we can not afford to keep a leisure class for certain desirable bye-products. It is in every way better and cheaper to pay for our science. Germany owes its leadership in the nineteenth century to the provision of highly regarded university chairs given as a reward and as opportunity for research.

Such opportunity for scientific research as exists in the United States is also chiefly due to the universities. Of our thousand leading scientific men, three fourths earn their livings by teaching, nearly all in a few universities. These institutions deserve credit for what has been accomplished and responsibility for the fact that we have failed to equal Germany, England and France in the production of scientific men of high quality. There are many positions and many scientific men, many students and many executive officers. But our colleges and professional schools are not of university grade, our graduate students are not the men of exceptional ability selected from the whole people, but, as a group, men preparing to follow a safe and humble career; safe, so long as no offence is given; humble, unless it leads to an administrative position. The professor is subjected to official routine and executive machinery; his salary, at best but meager, his work and even his position are dependent on the will of a superior official. We may hope that this is only a temporary phase in university development, corresponding to similar conditions in poli-

A Water-hen rising to the Surface.



A Seal plunging under Water.

Photographs of animals under water taken by Dr. Francis Ward and reproduced from a series in the *Illustrated London News*.

ties, business and society, not unnatural under rapid material exploitation in the childhood of a democracy. The danger is that great men may be lacking in our universities when the time comes for them to assume the place they should hold in the community.

Of our thousand leading scientific men, 739 are in educational institutions, 110 in government work, 59 in applied science, 38 in museums and gardens, 36 in research institutions, 18 are amateurs or in other professions. The conditions in the government service are somewhat similar to those in the universities. There are men and money in abundance, but mediocrity is favored rather than genius. In the establishment of endowed research institutions the United States has taken a forward step which may give to us the world's leadership in scientific research. In our research establishments, in our universities, in government, state and municipal service, in discovery through the application of science, we have possibilities never before presented to any nation. It will be well for us and for the world if these are realized in performance.

SCIENTIFIC ITEMS

We regret to record the deaths of Professor Robert Woodworth Prentiss, who had held the chair of mathematics and astronomy in Rutgers College since 1891; of Dr. George McClellan, a Philadelphia surgeon, known for his researches in anatomy, and of Dr. Adolf Slaby, professor of electrotechnics in the Berlin Technical School and the University of Berlin, known for his work in wireless telegraphy.

It is announced that Dr. H. B. Fine, professor of mathematics in Princeton University, has been offered by President Wilson the ambassadorship to Germany.—Dr. David F. Houston, secretary of agriculture, will retain the chancellorship of Washington University on leave of absence.—Professor Willis Luther Moore, who has been chief of the United States Weather Bureau since 1895, has been retired from this office.

The Bruce medal of the Astronomical Society of the Pacific has been awarded to Professor J. C. Kapteyn, of Groningen, for his work on the proper motions of the stars.—The Harris lecture committee of Northwestern University has announced that the Norman Waite Harris lectures for 1913–14 will be delivered by Dr. Edwin Grant Conklin, professor of zoology at Princeton University. The general subject of his lectures will be heredity and eugenics.

The university faculty of Cornell University passed on March 14 the following resolution:

Whereas: Professor Willard C. Fisher, a distinguished alumnus and former fellow of the university, has been dismissed from the chair of economics and social science at Wesleyan University on grounds stated in the letters of January 27, 1913, exchanged between the president of Wesleyan University and Professor Fisher; therefore,

Resolved, That the faculty of Cornell University extend to Professor Fisher greetings and assurance of regard, with the message that his *alma mater* still seeks to maintain and extend the spirit of liberality, toleration and loyalty to truth, illustrated by the principles and lives of its founders, Ezra Cornell and Andrew D. White.

THE POPULAR SCIENCE MONTHLY.

JUNE, 1913

SOME FURTHER APPLICATIONS OF THE METHOD OF POSITIVE RAYS[1]

PROFESSOR SIR J. J. THOMSON, O.M., LL.D. D.Sc., F.R.S.

CAVENDISH PROFESSOR OF EXPERIMENTAL PHYSICS, CAMBRIDGE, AND PROFESSOR OF NATURAL PHILOSOPHY, ROYAL INSTITUTION

THE method to which I shall refer this evening is the one I described in a lecture I gave here two years ago. The nature of the method may be understood from the diagram given in Fig. 1. *A* is a vessel containing the gases at a very low pressure; an electric discharge is sent through these gases, passing from the anode to the cathode *C*.

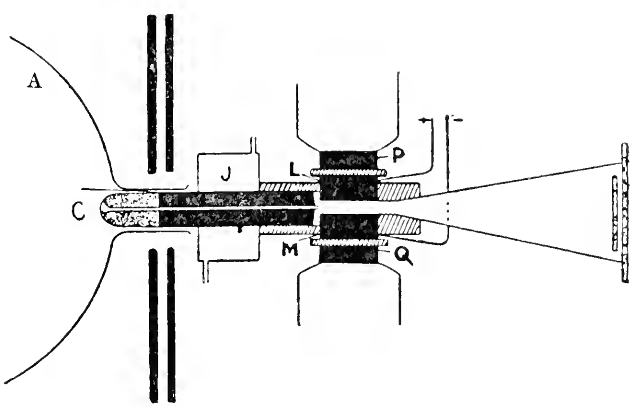


FIG. 1.

The positively electrified particles move with great velocity towards the cathode; some of them pass through a small hole in the center, and emerge on the other side as a fine pencil of positively electrified par-

[1] Address before the Royal Institution of Great Britain, Friday, January 17, 1913.

ticles. This pencil is acted on by electric forces when it passes between the plates *L* and *M*, which are connected with the terminals of a battery of storage cells, and by a magnetic force when it passes between *P* and *Q*, which are the poles of an electro-magnet. In the pencil before it passed under the influence of these forces there might be many kinds of atoms or molecules, some heavy, others light, some moving quickly, others comparatively slowly, but these would all be mixed up together. When they are acted on by the electric and magnetic forces, however, they get sorted out, and instead of traveling along the same path they branch off into different directions. No two particles will travel along the same path unless they have the same mass as well as the same velocity; so that if we know the path of the particle we can determine both its mass and its velocity. In chemical analyses we are concerned more with the mass than with the velocity, and we naturally ask what is the connection between the paths of particles which have the same mass but which move with different velocities. The answer is that all such paths lie on the surface of a cone, and that each kind of particle has its own cone; there is one cone for hydrogen, another for oxygen, and so on. Thus one cone is sacred to hydrogen, and if it exists there must be hydrogen in the vessel; so that if we can detect the different cones produced from the original pencil, we know at once the gases that are in the tube. Now, there are several ways of identifying these cones, but I shall only refer to the one I have used in the experiments I wish to bring before you this evening. These moving electrified particles, when they strike against a photographic plate, make an impression on the plate, and a record of the place where they struck the plate can be obtained. Thus, when a plate is placed in the way of the particles streaming along these cones, the sections of these cones by the plate (parabolas) are recorded on the photograph, hence we can identify these cones by the parabolic curves recorded on the photograph, and these parabolas will tell us what gases are in the vessels.

The first application of the method which I shall bring before you this evening is to detect the rare gases in the atmosphere. Sir James Dewar kindly supplied me with two samples of gases obtained from the residues of liquid air; the samples had been treated so that one might be expected to contain the heavier gases, the other the lighter ones. I will take the heavier gases first. The photograph for these is shown in Fig. 2. When the plate is measured up it shows a faint line corresponding to the atomic weight 128 (xenon); a very strong line corresponding to the atomic weight 82 (krypton), a strong argon line 40 (argon) and the neon line 20. There are no lines unaccounted for, and hence we may conclude that in the atmosphere there are no unknown gases of large atomic weight occurring in quantities comparable with those of xenon or krypton. This result gives an example

of the convenience of the method, for a single photograph of the positive rays reveals at a glance the gases in the tube. I now turn to the photograph of the lighter constituents shown in Fig. 3; here we find the lines of helium, of neon (very strong), of argon, and in addition there is a line corresponding to an atomic weight 22, which can not be identified with the line due to any known gas. I thought at first that this line, since its atomic weight is one half that of CO_2, must be due to a carbonic acid molecule with a double charge of electricity, and on some of the plates a faint line at 44 could be detected. On passing the gas slowly through tubes immersed in liquid air the line at 44 completely disappeared, while the brightness of the one at 22 was not affected.

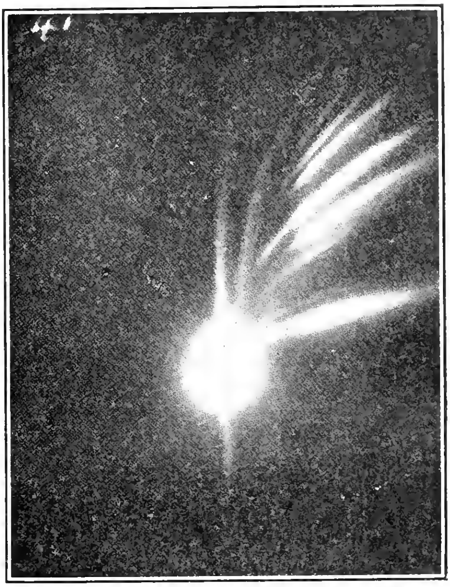


FIG. 2.

The origin of this line presents many points of interest: there are no known gaseous compounds of any of the recognized elements which have this molecular weight. Again, if we accept Mendeleef's periodic law, there is no room for a new element with this atomic weight. The fact that this line is bright in the sample when the neon line is extraordinarily bright, and invisible in the other when the neon is comparatively feeble, suggests that it may possibly be a compound of neon and hydrogen, NeH_2, though no direct evidence of the combination of these inert gases has hitherto been found. I have two photographs of the

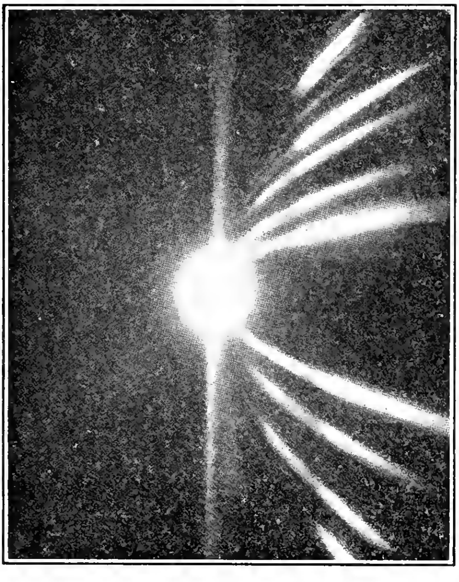


FIG. 3.

discharge through helium in which there is a strong line, 6, which could be explained by the compound HeH_2, but, as I have never again been able to get these lines, I do not wish to lay much stress on this point. There is, however, the possibility that we may be interpreting Mendeleef's law too rigidly, and that in the neighborhood of the atomic weight of neon there may be a group of two or more elements with similar properties, just as in another part of the table we have the group iron, nickel and cobalt. From the relative intensities of the 22 line and the neon line we may conclude that the quantity of the gas giving the 22 line is only a small fraction of the quantity of neon.

Let me direct your attention again to the photograph of the heavier gases in the atmosphere. You will notice that the parabolas corresponding to many of the elements start from points which are all in the same vertical line; this indicates that the atoms or molecules which form these parabolas all carry the same charge. Several of these lines, however, do not follow this rule; you will notice, for example, that the neon line has a prolongation which comes nearer than the normal line to the vertical line drawn through the undeflected spot. Measurement of the photograph shows that the neon line begins at a distance from this vertical line which is only half the normal distance; this shows that some of the neon atoms in the positive rings possess two charges of electricity; the majority of them, however, only possess one. If you examine the argon line you will find that it comes even nearer to the vertical than the neon line, in fact, it begins at a distance from the vertical only one third of the normal distance; this proves that the argon atom can have as many as three charges of electricity. If now you examine the krypton line you will find that it comes nearer to the vertical line than even the argon; its least distance is one fourth of the normal distance, showing that the krypton atom may have as many as four charges. The mercury line comes so close to the vertical line that it is only on large photographs that it can be seen that there is in reality an interval; this interval is only one eighth of the normal interval, showing that mercury may acquire eight positive charges, *i. e.*, that it may lose eight corpuscles. The mercury atom when it is on this line must have only the normal charge, *i. e.*, it must have regained all but one of the corpuscles it previously lost; if it had retained two positive charges it would have been on the line corresponding to the atomic weight 200/2 or 100; if it had retained 3, or 4, 5, 6, 7, 8 on the lines corresponding to the atomic weights, 200/3, 200/4, 200/5, 200/6, 200/7, 200/8 respectively. All these except the last have been detected on the plate. The lines corresponding to the multiple charges on krypton, argon and neon have also been detected. It appears, then, that in a vacuum tube a mercury atom, for example, may be ionized in two ways; in the one way the atom loses one corpuscle, in the other it loses eight.

I would suggest that these two types of ionization may result from the two different types of collision which the atom must experience. The first type is collision with a corpuscle; since the corpuscle is an exceedingly small body moving with a very great velocity, it can pass freely through the atom, and the collision it makes with the atom is really a collision with a corpuscle inside the atom; this may result in the corpuscle it strikes acquiring such a great velocity that it is able to escape from the atom; this type of collision will result in the detachment of a single corpuscle. The second type of collision is when the atom collides with another atom and not with another corpuscle; the result of this collision may be that the atom suffers a sudden change in its velocity. This change is not at first shared by the corpuscles, so that these just after the collision may have a very considerable velocity relative to the atom. If there are several corpuscles which are comparatively loosely attached to the atom, these may all be detached from it and leave it with a positive charge corresponding to the number shaken out. It is this type of collision which we regard as giving the multiply-charged ions, and we see that the magnitude of the charge is a measure of the number of corpuscles in an atom which are readily detachable from it. We have seen that the greater the atomic weight the greater the charge it can acquire, the maximum charge being roughly proportioned to the square root of the atomic weight, hence the heavy elements have a larger number of detachable corpuscles than the lighter ones.

Another application of the method I should like to bring before you is the use of it for the discovery and investigation of a new substance. I have in previous lectures said that sometimes there appeared on the plates a line corresponding to a particle with an atomic weight 3; this must either be a new element or a polymeric modification of hydrogen, represented by H_3. The other possibility that it is a carbon atom with four charges is put out of court by the fact that it frequently occurs when the carbon line is exceedingly faint, and when there is not a trace of a carbon atom with even two charges, though the doubly-charged carbon atom occurs readily under certain conditions. In addition to this, the carbon atom parabola never approaches the vertical near enough to allow of its having four charges. I thought the study of the substance producing this line would be of interest, and I have for some time been working at it, and although the research is by no means completed, I have obtained some results which I should like to bring before you.

At first I was greatly hindered by not knowing the conditions under which the line occurred: although it appeared from time to time on the plates, its appearance was always fortuitous and sometimes for weeks together the plates would not show a trace of the line. The line sometimes appeared, but why it did so was a mystery, and I could not get it when I wanted it. I began an investigation, which proved long and

tedious, to find the conditions under which the line appeared. I tried filling the discharge-vessel with all the gases and vapors described in the books on chemistry without success. At last I tried bombarding various substances with cathode rays. Under this treatment the substances give off considerable quantities of gas the greater part of which is hydrogen, carbonic acid or carbon monoxide. When I came to analyze by the positive rays the gases given off in this way, I found that with a large number of substances these gases contained the substances giving the three lines, so that I was now in a position to get this line whenever I wanted it, and investigate the properties of the gas to which it owes its origin. The question of the gases absorbed and given off by solids is an extremely interesting one, and a considerable number of investigations have been made on it. In all these, as far as I know, the method has been to heat the solid to a high temperature, and then measure and analyze the very considerable amount of gas which is driven off by the heating. As far as I know, no experiments have been made in which the gases were driven off by bombardment with cathode rays. This treatment, however, will cause the emission of gas even when ordinary heating fails to do so.

Belloc, who has recently published[2] some interesting experiments on this subject, after spending about six months in a fruitless attempt to get a piece of iron in a state in which it would no longer give off gas when heated, came to the conclusion that, for practical purposes, a piece of iron must be regarded as an inexhaustible reservoir of gas. There are some interesting features about the emission of gas from a heated solid. If the body is kept for a long time in a vacuum at a high temperature, the emission of gas becomes too small to be detected; if after this treatment the temperature is raised considerably, there will be a further copious emission of gas, which again diminishes as the heating continues. After it has fallen to zero, all that is necessary is to raise the temperature again and you will get a fresh supply of gas; and as far as my experience goes, after you have got all the gas you can out of the solid by heating it, you have only to expose it to cathode rays to get a fresh outburst. This effect of increased temperature in renewing the stream of gas from the solid seems to me to be too large to be accounted for merely by an increase in the rate of diffusion of the absorbed gas from the interior to the surface; it seems to be more analogous to the case of the emission of the water of crystallization from some salts. There are some salts, for example, copper sulphate, which when heated lose their water of crystallization in stages; thus, if the temperature is raised to a certain value, some of the water of crystallization comes off, but the rest remains fixed, and you may keep the salt at this temperature for ever without getting rid of all the water of crystallization; on

[2] *Ann. de Chimie et de Physique* (8), XVIII., p. 569.

raising the temperature, however, fresh water of crystallization is given off. Something of this kind seems to take place in the case of gases absorbed in metals, and there seem to be indications that there is some kind of chemical combination between the gas and the metal. This absorbed gas may influence the behavior of the substance. For example, an ordinary carbon filament gives off, when raised to a white heat, large quantities of negatively electrified corpuscles; but Pring and Parker[3] have shown that when great precautions are taken to get rid of the absorbed gas, the emission of these corpuscles falls to less than one millionth of their previous value. It is in the gases given off by certain metals when they are bombarded by cathode rays that I have found an unfailing source of the substance, which I shall denote by X_3, giving the line corresponding to the atomic weight 3. The arrangement I have used for investigating the presence of this gas is shown in Fig. 4.

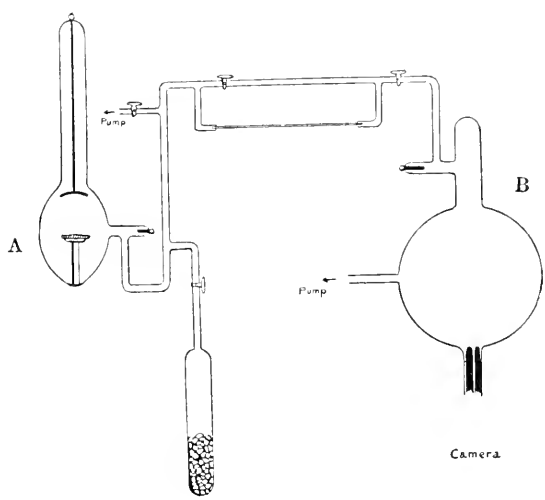
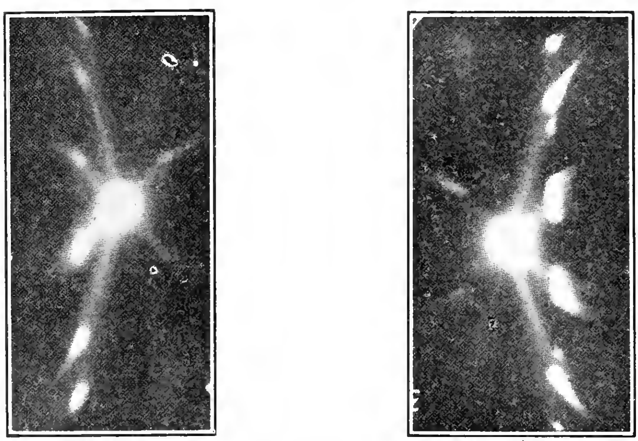


FIG. 4.

A is a vessel communicating with the bulb *B* in which the positive rays are produced by two tubes, one of which is a very fine capillary tube, while the other one is five or six millimeters in diameter; taps are inserted so that one or both of these vessels can be closed, and the vessels *A* and *B* isolated from each other. *A* is provided with a curved cathode such as are used for Röntgen ray focus tubes, and the cathode rays focus on the platform on which the substance to be bombarded is placed. [It is not absolutely necessary to focus the cathode rays in this way, but it makes the supply of the gas X_3 more copious.] After the metal or other solid to be examined has been placed on the platform, the taps between *A* and *B* being turned so as to cut off the connection between

[3] *Phil. Mag.*, XXIII., p. 192.

them, *A* is exhausted until the vacuum is low enough to give the cathode rays; the discharge is then sent through *A*, and the cathode rays bombard the solid. The result of this is that in a few seconds so much gas, mainly CO_2 and hydrogen, is driven out of it that the pressure gets too high for the cathode rays to be formed, and unless some precautions to lower the pressure were taken the bombardment would stop. To avoid this, a tube containing charcoal cooled by liquid air is connected with *A*, and this absorbs the CO_2 and enough of the hydrogen to keep the vacuum in the cathode ray state. To see what new gases are given off in consequence of the bombardment, a photograph is taken while the connection between *A* and *B* is cut off. After this is finished, and when the bombardment has gone on for about four hours, the tap is turned and a little of the gas from *A* is allowed to go into *B*; another photograph is taken, and those lines in the second photograph which are not in the first represent those gases which are liberated by the bombardment, and which have escaped being absorbed by the charcoal. I have here a slide (Fig. 5) representing the result of bombarding nickel. There are two



a *β*

Fig. 5.

photographs, one (α) before turning the tap and the other (β) after; in the second you see the three line very distinctly, while it is absent from the first, showing that the gas giving the three line has been liberated by the bombardment. I have got similar results to these when, instead of nickel, iron, copper, lead, zinc have been bombarded. I have tried two specimens of meteorites kindly lent to me from the Mineralogical Museum, Cambridge, and found there the three line. Nearly every substance I have tried gives, the first time it is bombarded, the helium line as well as this line due to X_3; if, however, the same substance is bombarded a second time, the helium line is in general absent (occasionally it is still to be detected, though exceedingly faint); and

on the third bombardment is invisible in all the substances I have tried except monazite sand, where it is given off in exceedingly large quantities as long as the bombardment continues. It is remarkable that monazite sand, which contains so many elements, gives no trace of the three line when bombarded.

I have also obtained the X_3 line and also the helium line when the tube *A* was replaced by one containing a Wehnelt cathode: with this the current of cathode rays through the tube was much larger than with the other cathode, though the velocity of the rays was smaller. The Wehnelt cathode gives the line without placing pieces of metal in the tube, so that in this case nothing is bombarded by the cathode rays but the glass walls of the tube; the strip of metal forming the cathode is, however, bombarded by the positive rays.

The three line when present at all continues even though the bombardment is very prolonged. In some cases the bombardment has been prolonged for twenty hours, and at the end of that time the line seemed almost as bright as at the beginning; indeed I could not feel certain that there was any difference. This might lead one to suspect that X_3 was manufactured from the lead or other metal by the bombardment rather than stored up in it, and this view might be regarded as receiving some support from the fact that very little of the X_3 is liberated by heating. The following experiment is an illustration of this. I took a piece of lead, and instead of bombarding it with cathode rays I placed it in a quartz tube connected with vessel *A*, and heated the tube to a bright red-heat for several hours. Large quantities of CO_2 and hydrogen were driven off by this process; this was absorbed by charcoal, and the residual gases, which had accumulated in *A*, were admitted into the vessel *B*; the X_3 line and helium line could just be detected, and that was all. I then gave the lead a second heating, raising this time the temperature until the quartz was on the point of softening. The lead was boiling vigorously; the heating was kept up for about three hours. In this time about three quarters of the lead had boiled away. I then let the gases which had been given off at the second heating into the vessel *B*, and took another photograph: no trace of the line due to X_3 or helium could be detected. The fraction of the lead which had not been boiled away was now placed in *A* and bombarded by cathode rays. It now gave the three line quite distinctly: the helium line was visible, but faint. By the bombardment with the cathode rays the lead was only just melted, so that the average temperature was much less than when it was heated in the quartz tube. This rather suggests that the X_3 might be due to a kind of dissociation of the metal by the cathode rays, and not to a liberation of a store of that substance. Another experiment shows, however, that for lead, at any rate, this view is not tenable. I took some lead which had just been deposited from a solution of lead

acetate by putting a piece of zinc into the solution, and forming the well-known lead-tree. When I bombarded this freshly precipitated lead, I could get no trace of the X_3 line; the helium line, too, was absent. I then tried another experiment. I took a piece of lead and divided it into two parts. The first of these I bombarded by the cathode rays: it gave the X_3 line quite distinctly. The other part I dissolved in boiling nitric acid, getting lead nitrate. The nitrate was heated and converted into oxide, and this was bombarded by the cathode rays: it did not give the X_3 line, showing that the X_3 is not produced by the bombardment, but is something stored up in the lead, which can be detached from it when the lead is dissolved. I have tried several samples of lead; the one which gave the X_3 line most distinctly was a piece of lead from the roof of Trinity College Chapel, several hundred years old. A sample of Kahlbaum's chemically pure lead, which must, I suppose, at no distant date have been subjected to severe ordeals by fire and water, showed the line quite distinctly, though not so well as the older lead. I have tried similar experiments with iron, and found that iron which gave the three line very distinctly ceased to do so after it had been dissolved in acid.

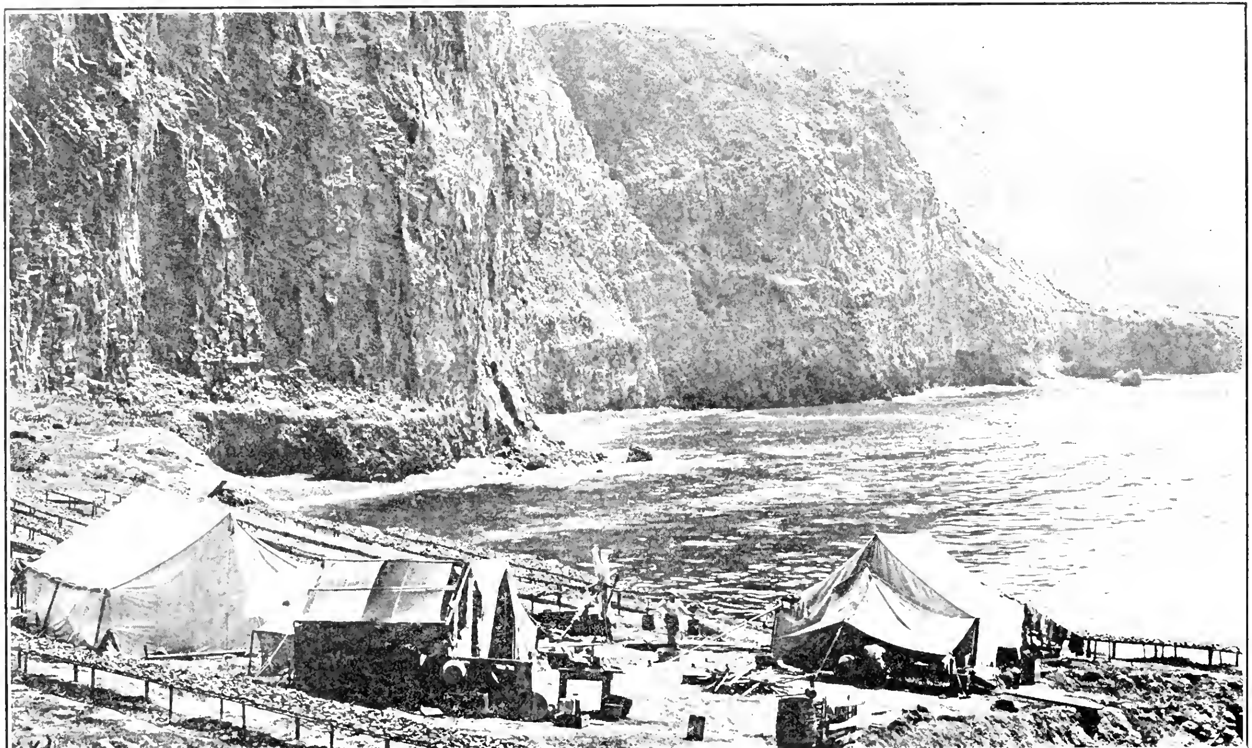
As the most obvious explanation of X_3 is that it is H_3, bearing the same relation to hydrogen that ozone does to oxygen, and produced in some way from the hydrogen dissolved in the metal, I tried if I could produce it by charging metals with large quantities of hydrogen, and then seeing if the hydrogen coming from the metal gave any traces of H_3. Thus, for example, I tested the hydrogen given off from hot palladium, but found no trace of X_3. I then charged nickel at a temperature of about 355° C. with hydrogen in the way recommended by Sabatier, but found no increase in the brightness of the X_3 over nickel that had not been deliberately exposed to hydrogen. I tried if the brightness of the line would be increased by adding hydrogen to the bulb *A*, in which the bombardment took place, but found no effect. I also tried adding oxygen to this bulb, thinking that if it was H_3 it would combine with the oxygen, and thus be eliminated, but no great diminution in the intensity was produced by this treatment. The gas seems quite stable, at least it can be kept for several days without suffering any diminution that can be detected; indeed, when once it has got into a bulb, there is considerable difficulty in getting the bulb free from it. It must be remembered, too, that by the method it is produced the gas is subjected all the time to electric discharges which would break it up unless it possesses very great stability. Thus if X_3 is a polymeric modification of hydrogen, it must possess the following properties:

1. It must be very stable.
2. It must resist the action of oxygen.

3. It must not be decomposed by long-continued exposure to the electric discharge.

These are properties which *a priori* we should hardly have expected an allotropic modification of hydrogen to possess.

Mendeleef predicted the existence of an element with an atomic weight 3. According to him this element should be intensely electro-negative and possess the properties of fluorine to an exaggerated extent. The gas X_3 can, however, be kept in glass vessels, which we should not expect to be possible if it possessed more than fluorine's power of combining with glass. I prefer to defer expressing any opinion as to the actual nature of the gas until I have had the opportunity of making further experiments upon it. It is only about two months ago that I found how to get the gas with any certainty, and, as the method involves long bombardments, each experiment takes a considerable time. This has prevented me from making several experiments which suggest themselves, and which ought to be made before coming to a final decision. I thought, however, that the investigation, though incomplete, might not be unsuitable for a Friday evening discourse, as the gas, whatever its nature, is certainly one of considerable interest, and its detection illustrates the delicacy of this new method.



The Japanese Camp at San Clemente Island.

THE ABALONES OF CALIFORNIA

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MEDICAL DEPARTMENT, THE UNIVERSITY OF SOUTHERN CALIFORNIA,
ASSISTANT, CALIFORNIA FISH AND GAME COMMISSION

THE abalone belongs to a family of marine snails, the Haliotidæ, which has many representatives in the waters about Africa, India, Japan and the neighboring islands. Six species and one variety have been described from the Pacific coast of North America, but none from the Atlantic coast. Under the name of ormers, sea-ears, or ear-shells, this gastropod occurs on the coast of France and among the Channel Islands, but the species are most abundant in tropical and semi-tropical regions.

The abalone is of importance because of its beautiful shell, polished as an ornament, or manufactured into many kinds of novelties and jewelry. Gleaming with the iridescence of the rainbow and the aurora this lovely shell is fit to be the chalice of Eos. Pearls may be secreted around foreign particles accidentally, or designedly, introduced between the mantle and the nacreous layer of the shell. The mollusk *Pholadidea* may bore through the shell and cause the formation of the blister-pearl, or we may bring about the same result by inserting a prepared form. Then the meat, either fresh or dried, is of much food value.

In the commercial fishery of abalones, one or more crews are employed, generally made up of Japanese, but sometimes of Chinese or American fishermen. The boat containing a crew is either rowed, or driven by motor, from the camp to the fishing grounds. The crew consists of the diver and his six assistants. When over the right bottom the diver is clothed with his suit, the helmet screwed upon the brass collar, the heavy lead breast and back weights adjusted, and the air-pump manned. One man takes the diver's signal rope, another the hose from the air-pump, and the diver, with a net attached to a rope and his shucking-chisel in hand, is assisted over the side, climbs down the short ladder and drops through the water to the bottom. If he finds the abalones plentiful, work is continued in depths of from twenty to sixty-five feet, in four-hour shifts. The man on the boat with the signal rope in hand follows the course of the diver by the constant stream of air-bubbles rising to the surface. When the kelp is thick one man has a knife on a long pole, with which he cuts the sea-weed and keeps the air-tube clear.

The diver finds it an easy task to detach the abalone from the rock

THE DIVER GOING DOWN THE LADDER.

if he pushes the shucking-chisel under the expanded foot before the animal is alarmed. If, however, the diver hesitates and the abalone contracts its muscular foot a powerful pressure is exerted. One or two cases have been reported of the drowning of Chinese fishermen who have had their hands caught by the abalone and thus held until overcome by the rising tide. The diver secures a net full of abalones, gives the signal and the mollusks are hoisted aboard and stowed below. The net, filled with about fifty green and corrugated abalones may be hauled up every six or seven minutes. During his shift below the diver gathers from thirty to forty basketfuls, each containing one hundred pounds of meat and shell, or altogether one and one half to two tons.

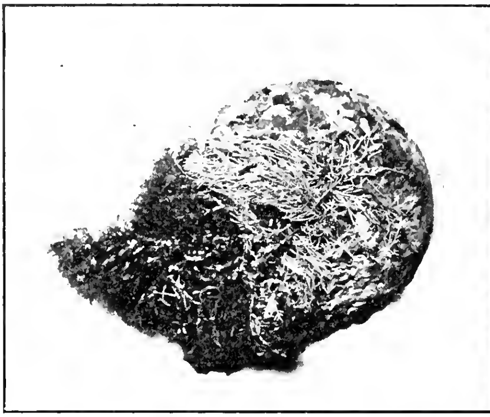
At Santa Catalina Island and later at San Clemente Island in company with a Japanese diver, I donned a diving-dress for submarine exploration. On one occasion the assistant failed to tighten the waist-belt which is designed to keep the air in the upper part of the diving-dress. The men at the pump worked with especial assiduity and as I dropped off the ladder the inflated rubber trousers turned my feet uppermost. Head down I went through sixty-five feet of water and then, not in a position for quiet reflection, remained some moments before the Japanese assistants concluded that my signals were not being made just for the fun of it. After being pulled to the surface, reversed and relieved of inferior inflation, a successful descent was made. The submarine journey is a wonderful experience. The bottom of the sea

seems made of grains of gold and silver, shimmering in the penetrating sunlight. Upon the face of a precipice, large specimens of the green and corrugated abalones rest. The shell of each is covered with a luxuriant growth of algæ, hydroids and tentacled tube-worms, which mask the creature from its enemies. All about are large fish which swim close and peer through the glass window of the helmet. An enormous sting-ray indifferently floats by. One has a fellow feeling with these unfrighted denizens of the deep in the fascination of observing their behavior under natural conditions.

In gathering abalones sometimes a crew is composed of six divers who work without suits up to a depth of twenty feet and some of them remain under water for as long as two minutes. These expert swimmers protect their eyes with glasses and wear cotton in their ears. They pry off the abalones with a shucking-chisel, often filling their arms on the way to the boat. Every two hours they return to the launch to be warmed at the fire. It takes the united efforts of these six men to equal the catch of one diver in a suit.

The abalone has a well-developed head and a powerful, adhesive, creeping foot. The shell is flattened, and the spire, which is such a prominent conical structure in most snail shells, is depressed and inconspicuous in this form. The last greatly enlarged whorl contains the body, especially characterized by the enormous columellar muscle, whose fibers run from their origin upon the muscle scar, or center of the shell, into the foot. Numerous contractile tentacles arise from the fringed epipodial fold, or ruff, around the base of the foot. The gills, alimentary system, reproductive glands, kidneys, heart and blood vessels and the pallial and visceral sections of the nervous system lie to the left of

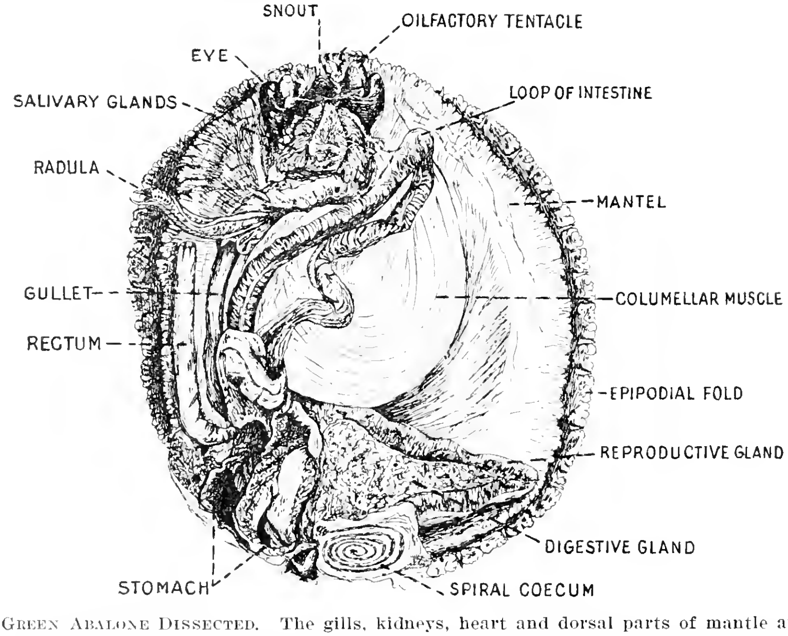
IN DIVING-DRESS READY FOR THE DESCENT.



The Green Abalone Shell with Mask of Algæ.

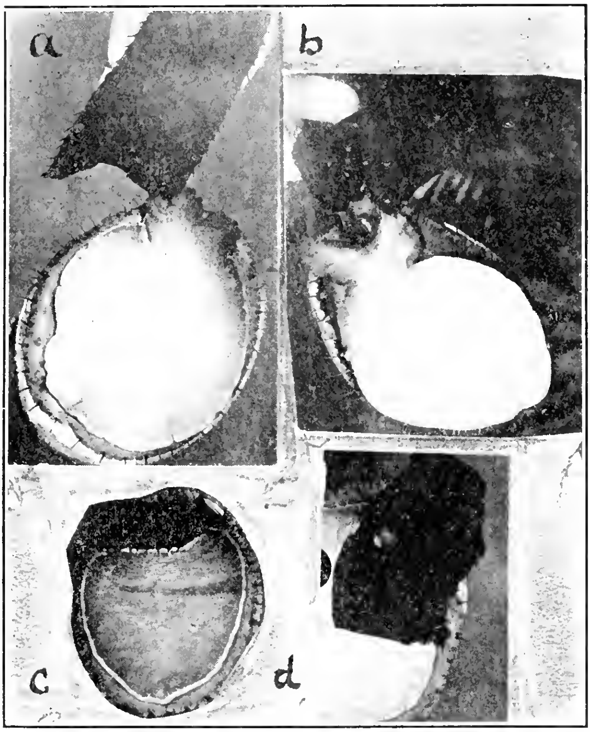
Black Abalone. Shell removed, showing visceral mass terminating in the spiral cœcum posteriorly and the opened gill cavity to the left anteriorly.

and behind the columellar muscle and foot. From the mouth cavity the gullet leads backward to the enlarged stomach, which is divided into two compartments, and receives the digestive juices from the large digestive gland at the hind end of the body. Two pairs of salivary glands pour their secretions into the buccal cavity. The intestine runs



Green Abalone Dissected. The gills, kidneys, heart and dorsal parts of mantle and columellar muscle have been removed and spiral cœcum turned over to the right.

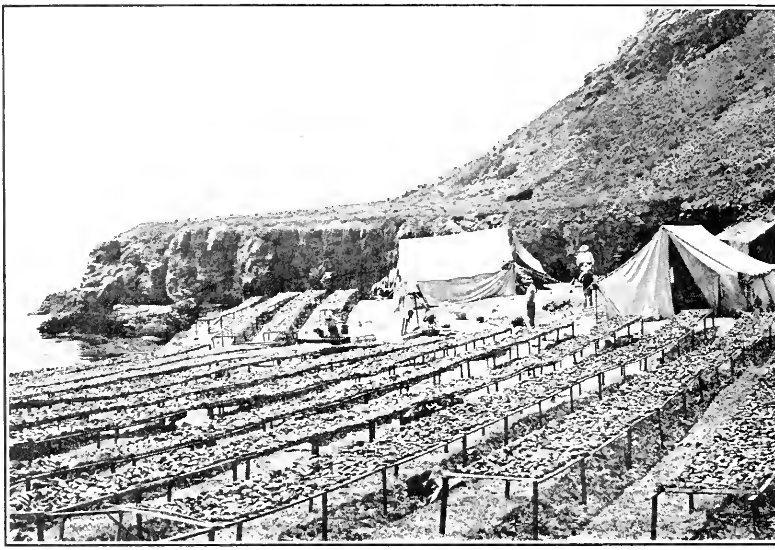
anteriorly to the side of the head, there turns on itself and proceeds back to the stomach, where it again goes forward, passing through the ventricle of the heart, to terminate in the anus, which opens into the gill cavity. The shell is perforated, toward the left, by a series of openings lying above a slit in the mantle fold leading into the gill cavity, whence issues a stream bearing the excrement, respiratory and excretory wastes. Three tentacular processes from the edges of



FEEDING ABALONES FROM THE HAND. *a, b,* grasping kelp with anterior processes of foot; *c,* drawing kelp under foot; *d,* eating hole in kelp.

the mantle cleft project through these holes. As the animal grows the apertures in the shell behind the respiratory cavity are closed up and new ones are formed at the anterior edge.

The head terminates in a short snout on either side of which is a somewhat slender olfactory tentacle and slightly lateral to this a shorter and broader optic tentacle. Two elongated ganglia lying above the mouth cavity may be called the brain because they form the center for nerves from the eyes, olfactory tentacles, snout, lips and other parts of the head. The eye is a simple cup-shaped depression of the epithelium on the end of the tentacle. The cup is filled with a gelatinous lens and it has clear and pigmented retinal cells connected with fibrils from the



THE ABALONE DRYING FRAMES OF THE SAN CLEMENTE ISLAND JAPANESE CAMP.

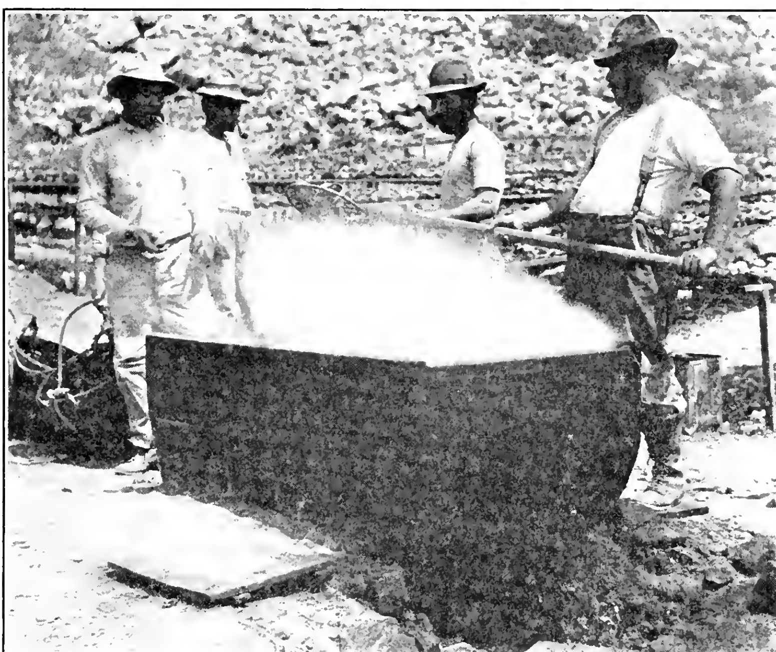
optic nerve. The shadow of a hand passing over the abalone in an aquarium causes the animal to contract the head end of the body. Hence the abalone differentiates various intensities of light and thus possesses a primitive sense of sight. The contractile tentacles running out in every direction from the ruff are end-organs of touch. Each has a nerve connected with either the right or left pedal cord. These two centers of innervation run through the middle of the foot for the greater part of its length and are connected by cross fibers. They not only recive stimuli from the sense organs of the ruff, but govern the multitude of muscle fibers which form the foot.

Scattered all over the exposed parts of the body are long spindle-shaped cells which may respond to such mechanical and chemical stimuli as to make of them indefinite end-organs of touch and smell. In the floor of the mantle cavity a water-testing sense organ, the osphradium, extends along the base of each gill. The cells of this simple end-organ are chemically stimulated in such manner that the abalone has sensations of smell, warning it to shut off the incurrent water, when foul or containing some poisonous matter.

If a piece of kelp is held motionless in front of the body, the animal soon responds by reaching out the cleft anterior portion of the foot. These finger-like processes grasp the sea-weed and pull it back beneath the mouth and foot, where it is firmly held. Cells in the mucous lining of the mouth cavity are stimulated so that the animal gets the sensation of taste. Covering the tongue is a long horny, file-like structure, the radula, with many thousands of chitinous teeth symmetrically ar-

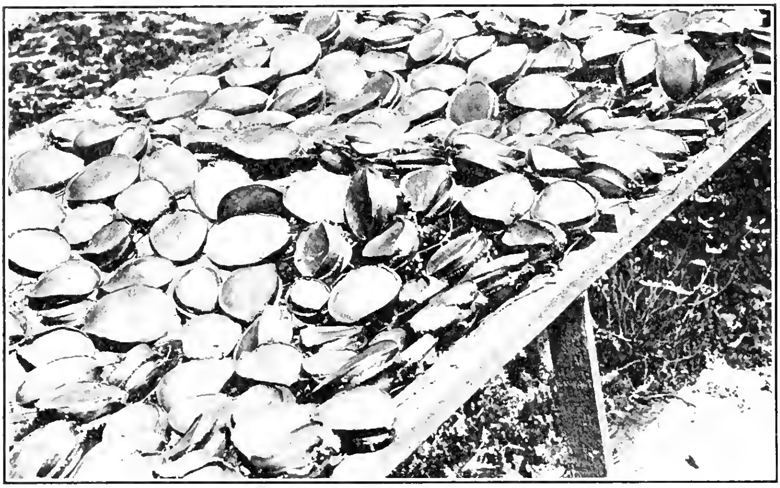
ranged in transverse and longitudinal rows. The teeth are pointed backward, and as the tongue is thrust out and drawn in, the radula rasps a hole in the succulent kelp, carrying the fragments of food to the opening of the gullet. Two chitinous jaws, one at either side within the mouth, but united in the midline, serve as scrapers to hold back in the mouth cavity the particles of food adhering to the radula. This method of feeding abalones individually by hand is of importance in easily caring for the animals in confinement in aquaria or in enclosed pools, or live-boxes in marine farming.

As food the abalone is one of the best of our marine mollusks. Detached from the shell, the visceral mass and mantle fringe are trimmed off from the large central muscle, which is then cut transversely into slices. These small steaks, when beaten four or five times with the flat side of a meat-cleaver and then fried in butter, are tender and delicious. The meat is also equally delectable when served as a chowder or minced. Besides supplying the local market the mollusks may be shipped across the continent, for when individuals are placed one on top of the other, in a sort of a living nest, they will survive for as long as six days without water, feeding upon the organisms and organic slime covering the shells upon which they rest. While the American market is not sufficiently developed to create an active demand



DIPPING ABALONES FROM THE BOILING TANK.

for fresh abalones yet in a dried state many are shipped to China. After being gathered from the rocks by the diver and taken into camp, the shells are removed and the abalones thrown into vats of salt water and left for two or three days. In this manner, the pigmented mantle fringe is removed and the meat preserved. The abalones are next washed in large tubs by means of wooden paddles and then cooked for one half hour in water almost at the boiling temperature not only for sterilization, but to give the meat the desired rounded shape. With dip-nets the Japanese workmen remove the abalones to baskets and

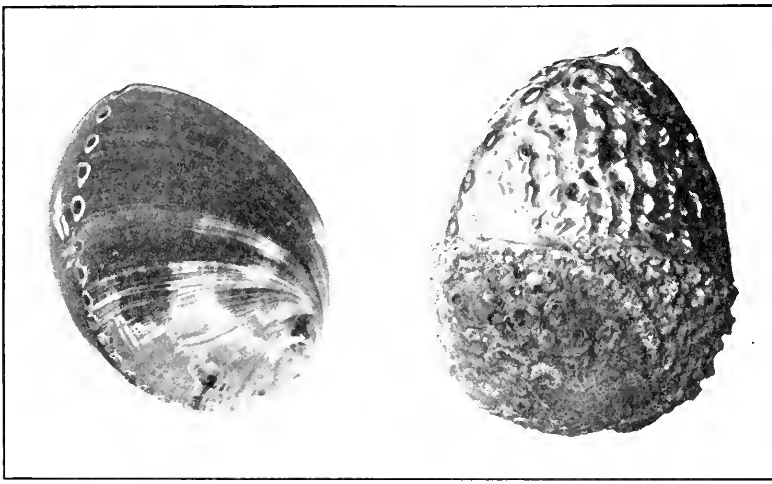


MEAT OF THE GREEN ABALONE DRYING IN THE SUNSHINE AT SAN CLEMENTE ISLAND.

carry them to the drying frames, where they are laid out in trays in the sunshine. After four or five days, or longer, if the temperature falls, the partly dried abalones are cooked in water for the second time for one hour. Next they are smoked in charcoal smoke for from twelve to twenty-four hours, and then for the third time placed in boiling water mainly for rinsing. Now they are dried for a period of six weeks and after a final cleansing bath in luke-warm water made ready for shipment. During the process of drying the meat loses nine tenths of its original weight. While hard and tough, like dried beef, it may be sliced with a sharp knife and eaten with relish. When dried the meat brings from twelve to fourteen cents a pound for the green and corrugated species, and from eight to ten cents for the black abalone. Most of the dried abalone goes to China and there finally, at retail, brings seventy-five cents per pound. A camp of fourteen Japanese fishermen brings in thirty tons, or more, of the fresh abalone in a month. There is considerable business in canning abalone for the California markets as well as for New York and Honolulu. The abalone of Japan,

the awabi, is a smaller species and the holes of the shell are relatively large, so that only the central part is of value, chiefly for use in inlaying. Gathering abalones is especially carried on by women divers, who swim out to the fishing grounds and work in depths of from six to eight fathoms. Pearls are not often found, but the meat is dried and sold as dark red disks strung on sticks.

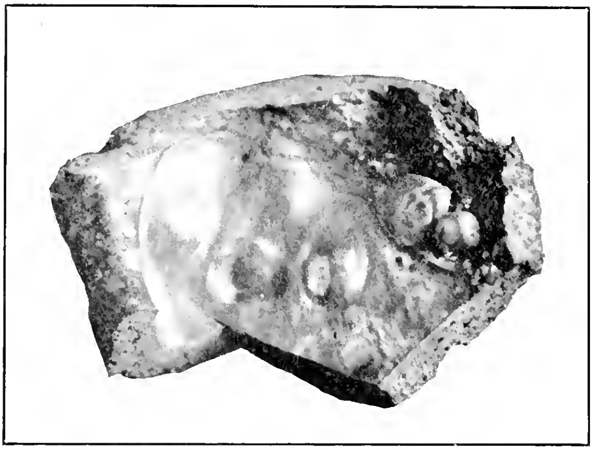
The familiar polished abalone shells have gone all over the world and everywhere are highly esteemed as ornaments. The shell is polished by grinding it first on a carborundum wheel until the desired colors are reached. The shell is then surfaced by a wheel of felt sprinkled with carborundum dust glued to the wheel. Finally it is



POLISHED BLACK ABALONE SHELL. SHELL OF THE CORRUGATED ABALONE. The unpolished posterior half showing incrusting worm tubes.

polished with a wheel made of many layers of cotton on the edges of which tripoli has been rubbed. This wheel is revolved about twenty-two hundred times per minute. The quality of being easy, or hard, to grind and polish is spoken of by the manufacturers as the texture of the shell.

The shells are sorted into two classes, but ordinarily classes one and two are mixed together. At Avalon, in 1870, when the meat sold for five cents a pound, the green shells brought eighty dollars a ton. At the present time the green shells are sold at one hundred and twenty-five to one hundred and eighty dollars a ton, the black, at eighty to one hundred dollars a ton, and the red, at forty to seventy-five dollars a ton. The black shells, with especially good pearly centers, bring from three hundred to five hundred dollars a ton. Owing to the increasing scarcity

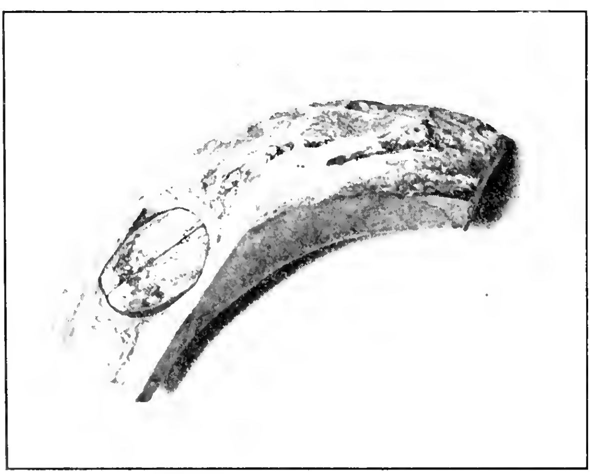


A Portion of the Red Abalone Shell with Four Blister-pearls and Two Free Pearls.

of good green shells, there is a growing tendency to use the centers of the red shells for jewelry.

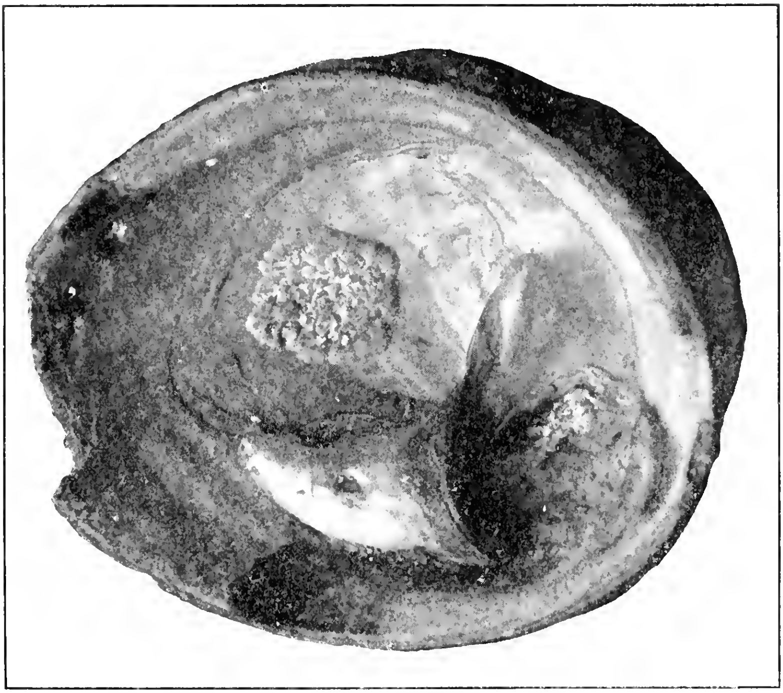
When the shells are cut into ornaments, as many as fifteen pieces, including one scimitar-shaped paper-knife made from the lip, or rim, may be produced from one shell of about twenty-two inches in circumference. At an average retail price of fifty cents for each of these pieces the products of the shell would realize seven dollars and fifty cents.

The blister-pearls are more or less extended elevations of the inner,



Shell of Red Abalone Opened to show a Razor-clam Shell Forming a Blister-pearl Nucleus.

pearly layer of the shell, formed by the secreting cells of the mantle in defense of the invading, boring mollusk, *Pholadidea parva*. They occur mostly in the red abalone, with only one blister-pearl in about a thousand shells of the green or black species. A crab, which infests the abalone at certain seasons, may be the cause of such formations, and one exhibited the complete outline of such a crab. Frequently the blister-pearls are formed over sea-urchin spines, chiton or razor-clam shells,

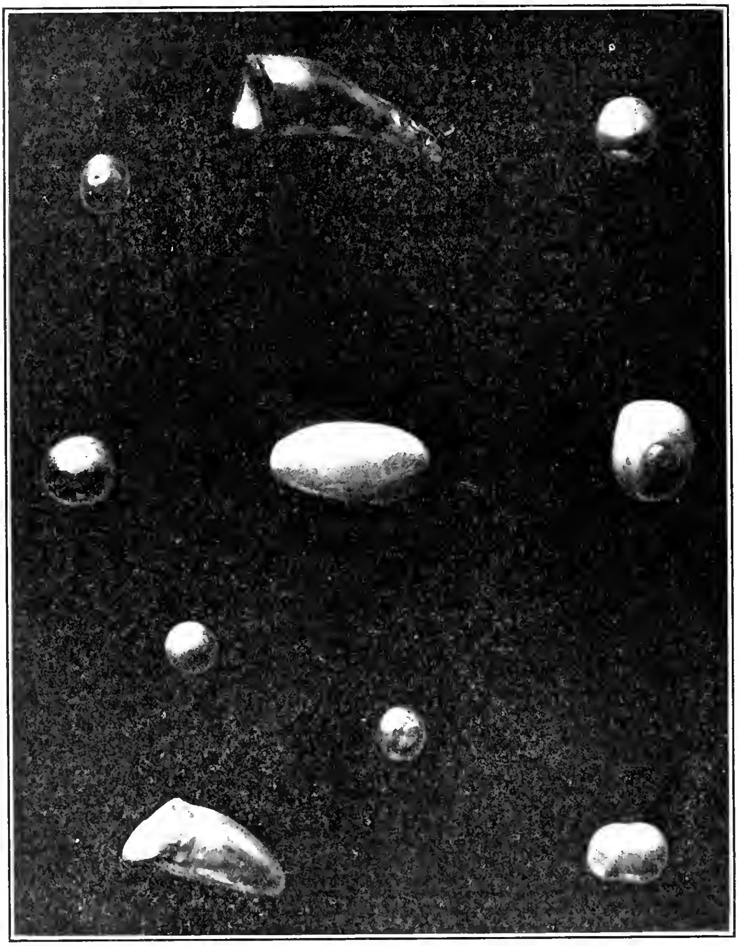


BLISTER-PEARL FORMED OVER A DISEASED VISCERAL HUMP.

pebbles and other foreign bodies retained beneath the mantle. Sometimes a diseased visceral bump is cut off and covered by nacre, making a huge blister-pearl.

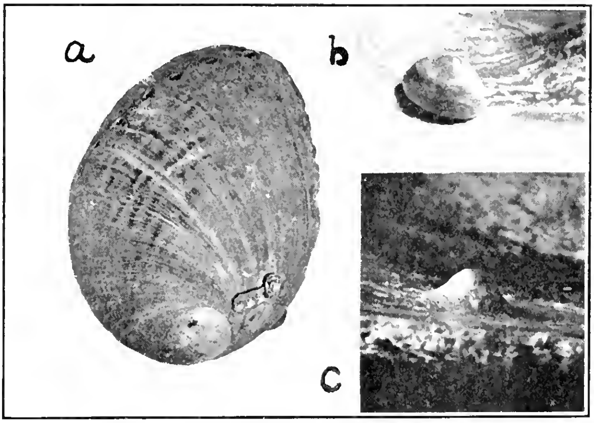
The free pearls have the color of the inside layer of the shell, varying from white, to green, or pink, according to the species. They sell from fifty cents, for the smaller ones, to one hundred and twenty-five dollars for one of twenty-five grains. Occasional pearls are so large and of such fine quality as to sell for five hundred, or even one thousand dollars. The free pearls are frequently found within the stomach. During the year 1912, over eighty-six thousand blister pearls and four thousand free pearls have been obtained from the abalone fishermen.

The origin of pearls has been a matter for speculation during many



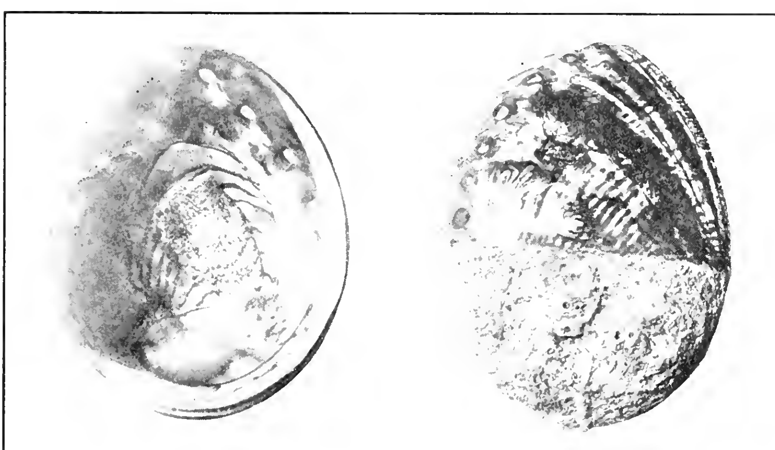
FREE PEARLS FROM THE ABALONE. The central pearl large and valuable. From the collection of C. B. Linton.

centuries. As related in ancient folk-lore, the pearl-oyster, rising to the surface of the sea in the early morning, opens wide the valves of its shell, so that dew-drops may fall within. Under the influence of the air and warm sunshine lustrous pearls develop from these glistening drops of dew. The pearls are white when the weather is fair, but dark if it is cloudy. This belief was held from the first to the fifteenth centuries, when the theory was advanced that the eggs of the pearl-oyster serve as nuclei for pearls. About the middle of the sixteenth century Rondelet concluded that pearls form from diseased concretions, and then, in 1600, Anselmus de Boot demonstrated that they are made of the same substance as the shell. Réaumur, in 1717, showed by aid of the microscope that the pearl is composed of concentric layers of



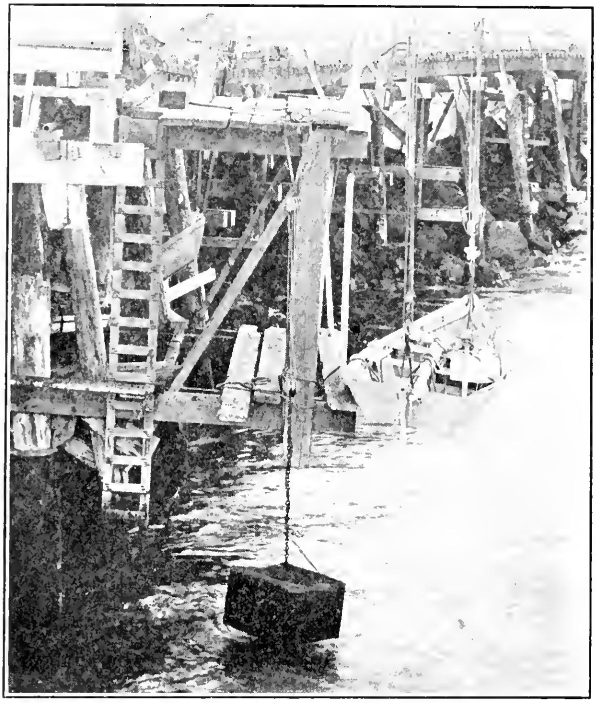
(*a*) Black abalone shell with pearl form inserted. (*b*) Head of shell pearl form on inner side of black abalone shell. (*c*) culture pearl formed in the green abalone in seven months.

nacre which we now know serve as minute prisms to split up the white light into the rainbow tints so beautiful when reflected from the surface of the pearl. In the middle of the nineteenth century from an investigation of the fresh-water mussels of Turin Lake, Filippe proved that the stimulus for pearl formation in that species is a trematode worm. Other naturalists, Küchenmeister, 1856, Möbius, 1857, Kelaart and Humbert, 1859, Garner, 1871, Dubois, 1901, and Giard, 1903, have contributed to our knowledge of the origin of pearls from parasitic nuclei. In 1902, Jameson traced the life history of a *Distomum* from its first host, a duck, to a clam as its second host, and he succeeded in



Interior View of the Red Abalone Shell, showing pearly center within the muscle scar.

Shell of the Green Abalone. The anterior portion polished.



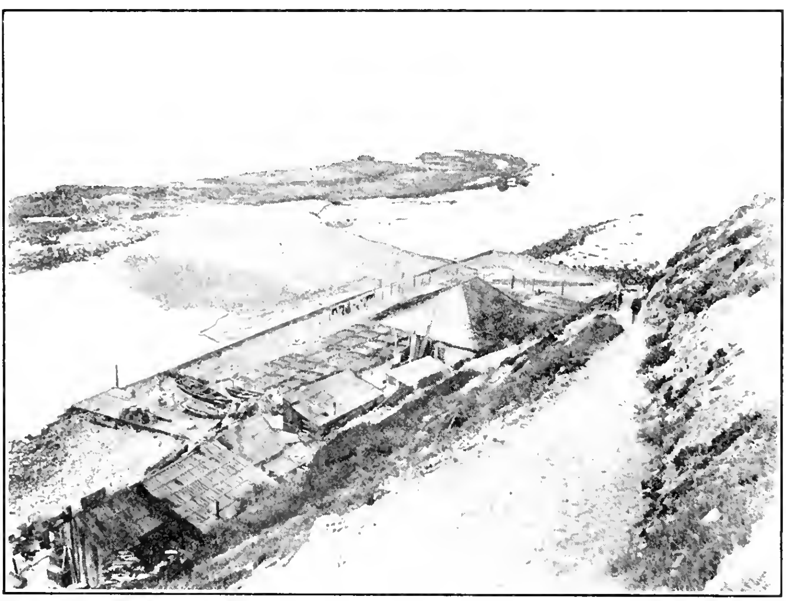
THE CONCRETE LIVE-BOX ABOVE WATER AT LOW TIDE.

inoculating the edible mussel, *Mytilus*, by placing it with parasitically infected mollusks and thus artificially induced the formation of pearls. Herdman, in 1903, found in the pearl-oysters of Ceylon that a tapeworm larval cyst may become a pearl nucleus, or that in some cases the secretions may be deposited around sand grains, bits of mud or a fish or some other small animal, in pockets of the mantle epidermis, or again about calco-spherules near the muscle insertions. The surface finally becomes polished, or takes the "orient," and thus reflects the opaline and nacreous tints so highly prized.

The production of culture pearls dates back to the fourteenth century in China and it is probable that the Arabs had a similar industry. The Chinese open the shell of the river-mussel, push back the mantle and introduce metal images of Buddah which are covered with nacre in the course of six months. Linné drilled a hole through the shell and inserted a pellet of limestone on the end of a silver wire so that the nucleus might be kept free from the shell during the secretion of nacre. In more recent times the secretion of culture pearls has been induced in pearl-oysters by similar methods in various countries. Bouton, in 1897, at Roscoff, France, bored small holes through the shell of the abalone and inserted forms made of mother-of-pearl. After

some months beautiful pearls were secreted, their size being in proportion to the length of time of the culture.

In our red abalone a boring mollusk, *Pholadidea,* penetrates the shell from the outside. It files its way, by means of sharp teeth on its shell and possibly by the secretion of sulphuric acid. The burrow enlarges, as the *Pholadidea,* growing in size, digs its way in. When near the inner pearly layer of the abalone shell, the host resists the oncoming *Pholadidea* by secreting more nacreous matter. Thus the defensive wall, eaten by the *Pholadidea,* grows inwardly as a mound-shaped projection, the blister-pearl. In imitation of this natural process, a hole is drilled through the abalone shell and a form is inserted. This form, made of shell, is shaped like a long-shanked collar-button and so placed that the expanded curved base lies against the pearl-secreting mantle. The shank projects from the outer surface of the abalone shell and is there made fast by aluminum wire, to which a metal tag, bearing the serial number, is attached. In some cases the wire has corroded, with the loss of the tag. In later experiments the numbers have been filed upon the shell. The black abalone has been used in most cases, although a few experiments have been made upon the green abalone. Holes have been drilled through various parts of the shell and different numbers of forms inserted. In addition, spherical forms, without shanks, have been placed beyond the mantle cavity near the visceral hump. I have succeeded in raising abalone culture



THE JAPANESE ABALONE CAMP AT WHITE'S POINT, CALIFORNIA.

pearls in one hundred and thirty-three days. These pearls, however, are thin layers of nacre, formed over a horny basis, which is the first material to be secreted. In the natural process of continued deposition they increase in thickness and solidity and consequently in value. One produced in a green abalone in seven months shows good form and luster. My average time for drilling a hole in the abalone shell, inserting the form and wiring it in place with the numbered metal tag, is eight minutes. This working time might be decreased by an expert laborer doing nothing else, so that the business of raising pearls would be of interest and profit. Mr. C. B. Linton has succeeded in producing similar culture pearls by drilling a hole through the shell center, pushing in a round ball, made from shell, and filling the outside end of the hole with beeswax and cement.

Based upon the fact that each ton of abalone shells represents a certain value of manufactured jewelry and novelties, it is possible to estimate the value of the abalone industry. Shells of the black abalone are sorted into two classes. Each ton of those with fine, pearly centers will make novelties and jewelry worth, at retail, four thousand dollars. The class known as button shells, with plain mother-of-pearl surface, represents a final value of one thousand dollars and the shells of the green abalone, three thousand dollars. For the fiscal year ending in July, 1912, the following shipments were made from Long Beach and represent the given valuations in manufactured products: thirteen tons of pearl center black abalone shells, fifty-three thousand dollars; forty tons of button black abalone shells, forty thousand dollars; fourteen tons of dried abalone meats at two hundred dollars a ton, twenty-eight hundred dollars; a total of ninety-five thousand eight hundred dollars. The shipping statistics are not complete for the other California ports, but it is demonstrable that the abalone industry may be developed into one of great value.

Much has been said recently in the newspapers concerning the threatened extermination of the abalone. That this is a real danger, and not an idle theory, is apparent to any one familiar with the facts. For instance, near Avalon, Santa Catalina Island, not more than twenty years ago, the green and corrugated abalones were so thick that they rested upon one another four or five deep, all over the rocks. After much searching in this locality during the last year I was unable to find a single specimen. The shells brought up by the divers of the glass-bottomed boats, and eagerly bought by the tourists, have been placed in position previously by the enterprising management. Great shell heaps on San Clemente, San Nicholas and other islands prove the abundance of abalones during the centuries of Indian occupation. Some of the red shells found are unusually large, measuring from twenty to thirty inches in circumference. Necklaces of large abalone

pearls have been found with the remains of Indians. If only well preserved, some of these pearls at present would be worth as much as five hundred dollars.

In many places where the abalone was formerly abundant, the large individuals of legal size are taken and it may be true, as in the case of the American lobster, that in this manner the most prolific breeders are sacrificed. We do not yet know anything about the breeding habits and embryology of any species of abalone, and hence are not certain as to the best months for a closed season. In time, without doubt, we shall be able to artificially propagate the abalone, as has been done with the oysters, clams, lobsters and other useful animals. The government breakwater, at the mouth of Los Angeles harbor, at San Pedro, has become a natural breeding ground for black abalones which creep back under the great stone blocks and thus escape the gatherers, who are stripping every accessible niche and cranny along the coast at each low tide during the open season.

Reservations have been established at Monterey Bay and Venice, but the present laws are inadequate for their best development. By act of the city trustees, the Venice breakwater has been made a biological reservation under the control of the marine biological station of the University of Southern California and guarded by a deputy of the State Fish and Game Commission. As an aquacultural experiment I have placed colonies of several hundred black abalones and seventy-five of the green species upon the submerged rocks. A large concrete live-box has been suspended by a block and tackle hoisting apparatus at about the mid height of the tide. The open top is covered by heavy galvanized iron meshwork, while through several holes in the botton the dirt is cleaned out by the flow of the tide. The box is so heavy that one may stand upon any part of it and do the necessary work in feeding and observing the animals within. Forty abalones under experimentation and for growth records are kept in the live-box and a group of two or three times that number might easily be maintained in good condition. Near Venice the ocean is shallow, for it is three miles out to the sixteen-fathom line. The trawling of our motor-sloop, the *Anton Dohrn,* has demonstrated that in most places the fauna of the sandy bottom is poor. Better results may be looked for when reservations are located on the rocky coast, where great beds of kelp thrive just within the deep-water line. The kelp is not only important as food for abalones, but within its wide spreading fronds a world of living things thrive. In such a region the plankton is richer and these microscopic plants and animals generate food for the larger swimming and bottom-dwelling forms.

The establishment of laws for the regulation of aquaculture and the concomitant protection of marine and fresh-water organisms is of

primary importance. The formation of reservation districts for absolute closure during successive periods of years, within which we may have, every five or ten miles, smaller perpetual biological reservations for breeding centers, will solve the problems of preservation in a better manner than the present laws for closed and open seasons. In Germany the Elster River pearl mussel beds and in France the marine mussel and oyster fisheries have been saved and developed by proper legislation and governmental supervision. In this country the business of oyster propagation and farming has been profitably established under such well-developed laws as those of Connecticut. It would be difficult to attempt an estimate of the remarkable achievement of the Bureau of Fisheries in the field of aquaculture. The shad, the salmon and now the fur-seal have been saved from extermination. So abalones may be raised in the sea as easily as chickens upon the land. The coastal waters must be surveyed for leasing by the state and then a police force organized to guard the marine farms from all the poaching pirates. It can not be emphasized too often that in direct ratio with the increase of population the neglected food resources of land and sea must be conserved and developed. The company manufacturing rubber and fertilizer and extracting iodine from kelp should only be allowed to cut the seaweed under such restrictions as will preserve the natural home and food supply of all the countless dependent organisms. The inherent tendency of man to rob the earth and sea in order to promote his own selfish interests must be restrained for the larger benefit of his fellows and the salvation of his descendants from want. The sea is the last great field for human exploration and exploitation. We know so little of its vast resources that we can scarcely dream of the possible future industries which will arise under a wisely administered system of aquaculture.

THE PRESIDENT OF THE NINTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY

By Dr. GEORGE FREDERICK KUNZ

NEW YORK CITY

THE newly elected president of the Ninth International Congress of Applied Chemistry, Professor Paul Walden, was born near Riga in the Russian province Livonia July 27, 1863. Hence, although of German blood, he is by birth a Russian. He first attended the Real School in Riga, and then the Polytechnicum there, where he was one of the most apt and brilliant pupils of the great Ostwald. In Riga, he was assistant in the department of physics in 1885, and in 1888 in that of chemistry; in 1892 he became Privat-docent, and in 1894 professor of analytical and physical chemistry. Since 1896 he is assistant professor of inorganic and physical chemistry, and at the same time director of the Polytechnicum.

When Ostwald resigned his professorship of chemistry at the Polytechnicum, Walden became his successor, and the latter still holds this position at the present time. He received his degree of doctor of philosophy at Leipzig in 1891, that of master of chemistry at Odessa in 1893, that of doctor of chemistry at St. Petersburg in 1899 and that of doctor of engineering at Riga. The remarkable work performed by Professor Walden has been officially recognized by the bestowal of many important Russian orders; he is a commander of the Order of Vladimir and also of those of St. Anne and of Stanislaus. He is a member of the Russian Academy of Sciences at St. Petersburg, and has laboratories both in Riga and in St. Petersburg. He is an honorary member of the London Chemical Society and of many other societies, and was selected as the Imperial Russian delegate to the Eighth International Congress of Applied Chemistry.

Professor Walden speaks Russian, Livonian, French and German fluently, and is familiar with English and Italian as well. In manner he is quiet, dignified and gentle, but alert and quick in his movements. He is about five feet eight inches in height and weighs some 175 pounds. His brown hair is brushed high on his forehead; he has light blue-gray eyes and fine teeth. He is a very fluent and ready speaker, and his delivery is at once easy and impressive. Always speaking directly to the point, his words are so well chosen and effective that invariably he holds the attention of his audience; there never can be any doubt as

PROFESSOR PAUL WALDEN.

to his meaning. The directness of his thought finds corresponding expression in his words and they carry conviction to the minds of his hearers, while his kindly smile serves to enlist their sympathies and approval.

His greatest work has been in stereochemistry. His work on the atomic transformation, the theory of solutions and other great problems is now classic. His literary activity has covered a wide field and he is the author of more than two hundred original scientific articles or books, nearly all on the subject of chemistry: physical chemistry, biochemistry and stereochemistry. For many years past his contributions to periodical publications such as the *Berichte der deutschen chemischen Gesellschaft,* Ostwald's *Zeitschrift für physicalische Chemie,* Lorenz's *Zeitschrift für anorganische Chemie,* etc., have been of the very highest value to science.

The biographical memoirs he has written of the eminent French chemist Berthelot, whose name is indissolubly associated with the science of thermochemistry, of the great Pasteur and of the celebrated propounder of the periodic law, the renowned Russian chemist Mendeleef, testify eloquently to Walden's intimate knowledge of the life and work of these great leaders of modern science.

Together with Carl Adam Bischoff, Professor Walden published his monumental work, the "Handbuch der Stereochemie," ably treating of this intricate and fascinating department of science. On the twenty-fifth anniversary of the doctorate of Professor Ostwald, whose most brilliant and successful pupil he is, Walden issued his excellent biographical sketch of that great physical chemist and philosopher, and, we may add, enthusiastic Esperantist. Ostwald has said that he owes fifty per cent. of his reputation to Walden's biography. At this time Ostwald was appointed a director of the Polytechnicum, an honor enjoyed only by himself and three others, namely, Aristes, Arrhenius and Teppler.

Besides his original work, Walden has translated into the Russian language Fischer's "Organic Preparations," and also the renowned Lowell lectures by J. H. van't Hoff, delivered in Boston.

Russians are the best hosts in the world. Whereas, in the United States the expenses of the congress were born by the American committee and their friends, in Russia, where the railroads are owned by the government, during the late International Geological Congress the freedom of the railroads was offered to the visiting guests.

St. Petersburg, a magnificent city with its great museums, universities, art galleries and other institutions, will be a splendid meeting place, and the excursions that can be made from it will prove of the greatest interest and value to the visiting guests.

In accepting the office of President of the Ninth International Congress of Applied Chemistry, Professor Walden made the following remarks:

> The choice which has just fallen upon me is a distinction of an altogether exceptional kind, and also a task of an exceptional kind. On behalf of Professor Konovaloff, who is absent, and who will assuredly regret his inability to take part in our common celebration, I can only express to you his thanks and his undoubted acceptance. In my own case, however, I realize mixed emotions. I say to myself: "Much honor, much work; many disappointments, many gray hairs!" In accepting this choice, we are fully aware that our powers will prove insufficient to do full justice to the duties entailed, but we see therein an honor rendered to our fatherland and to the great men, the great chemists of our country. I need only recall to your minds a few names; that of Lemonossoff, who one hundred and sixty years ago laid the foundation of modern chemistry; that of Grotthus, a Russian chemist of a century ago; that of Hessen, also a chemist, and finally I name to you our great fellow-countryman, recently deceased, Mendeleef, the creator of the periodic system of the elements. I assume that the honor you have just accorded to our fatherland is also addressed to these great men. We are the inheritors of the deeds these men accomplished. It is not the mind alone that rules congresses, the heart also must have its say. Of the scope of my mind, I am, naturally, not qualified to speak, but in what concerns my heart, in what concerns my ardent wish to do my best, to give you the best possible reception, as to this I believe I can safely speak, as to this I shall willingly and gladly compete with the gentlemen who have received us in former congresses, and if three years hence, in transmitting my office into other hands, I may perhaps be able to speak in my turn with the sunny humor of our president of to-day, then I shall be content. I thank you.

As the leader, director and presiding officer of the Ninth Congress of Applied Chemistry, Professor Walden possesses many notable qualities which must aid in rendering that congress a success. With its complex composition, made up as it is of as many, or perhaps more countries than there are known chemical elements, we might say that no one was better qualified than Professor Walden, with his intimate knowledge of the art of combining and ordering the various chemical elements, and we have no doubt that he will be equally successful with the various and eminently individual human equations in the congress, and that they will be so welded as to constitute a thoroughly homogeneous assembly, which will be brought to a close in a manner satisfactory to all, after the members shall have given free and full expression to their views.

The eighth congress had to decide whether four or but three official languages should be recognized, and the action finally taken favored the recognition of four—English, French, German and Italian. At the ninth congress many interesting matters will have to be discussed and determined; one of the most important contemplates the securing of an agreement among scientists to accept a standard determination of atomic weights by successive congresses, the weights recognized as au-

thoritative by any one congress to be regarded as such until changed by a succeeding congress. By this means a general rule would be established which would govern the use of atomic weights both industrially and scientifically. The eighth international congress strongly advocated and recommended the adoption of standard governmental examination of ores, metals and fuels. This is highly important for the avoidance, or at least for the decision, of disputes as to the relative richness of the various deposits, and also for the proper and consistent utilization of national resources in such materials.

For the ninth congress will remain the question as to the proper placing of the international delegates. Then the proper assignment of the papers to be read is to be considered, so as to determine and define the priority of one nation over another in regard to recent scientific or industrial discoveries in any one of the hundred or more special fields of experiment and research so ably exploited by the industrial giants who make up a congress such as the eighth International Congress of Applied Chemistry, which has just closed with absolute harmony. This was due in great measure to the splendid leadership of the retired president, Dr. William H. Nichols, who was the cornerstone as well as the central figure of this congress, and who with remarkable tact and ability steered the ship of this great congress safely into the port of the ninth international congress.

The following is a list of all the International Congresses of Applied Chemistry:

No. of Congress	Date	Place
First	1894	Brussels
Second	1896	Paris
Third	1898	Vienna
Fourth	1900	Paris
Fifth	1903	Berlin
Sixth	1906	Rome
Seventh	1909	London
Eighth	1912	New York City
Ninth	1915	St. Petersburg

[1] For a further discussion of the chemical and other international congresses, see "International Congresses," by Dr. Charles Baskerville, *Science,* N. S., Vol. XXXII., No. 828, pp. 652–659, November 11, 1910.

THE AMERICAN COLLEGE, AS IT LOOKS FROM THE INSIDE

By Professor CHARLES HART HANDSCHIN
MIAMI UNIVERSITY

THE future of higher education in America depends upon the position we shall grant to the college and university professor. The growing conception that the faculty—not buildings, nor advertisements, nor pyrotechnic display—but the faculty, makes the school is bound eventually to be accepted.

But before a faculty can make a school, it must be a real *collegium,* a corporation of teachers, besides whom everything and every one in the school is insignificant, their wards excepted, who, however, are *wards.*

On the other hand, it is all very well for professors to talk about being the big part of the show, bigger than the students, the equipment and the administration. We believe they should be, but we do not believe they should be, unless they are. A weak faculty can not direct the course of a school nor wisely elect additional members to their own body.

To qualify to do this, there must be, first, thorough scholarship—not $800 to $2,000-a-year scholarship, but $2,500 to $5,000-a-year learning. A mercenary view, you say. Granted. But it is the only one that has any weight with the majority of your good constituency. In our day a professor, as well as any other man, is respected according to the salary he can command. Gainsay it who can.

But you say, "Where does the college professor's idealism come in?" Why, it doesn't come in; it's gone, and you drove it out of the back door. You have respected him as he has been able to have a fine house, and all talk of his working for the love of learning—and poverty—is fol-de-rol. $2,500 to $5,000-a-year scholarship it must be, or be held in disdain by the butcher, the baker and the candlestick-maker, and any one else who can "sport" a "machine" and dress his women folk in the latest creations.

But beyond scholarship the faculty needs a sense of dignity as a body. Professors, as a rule, nowadays, are not overburdened with personal dignity. In our democratic rage to level all classes downward, we have levelled the college professor from his one-time dignified manner and station to the *niveau* of the untrained and unfinished student and the unmannered and illiterate townsman. Your professor slaps his darky laborer on the back with the manner of a pal, he addresses his students as "fellows," he puts his feet upon the table in his class-

room, he howls and even cusses on the foot-ball field—and if he does not do these things, you and your callow sons will rise up to boycott him and dub him "uppish."

But if professors are not overburdened with personal dignity, the sense of dignity and the right to be respected and heard as a body in the faculty is positively wanting. This is true not only in a few schools, but, almost without exception, in all. The trouble, as indicated, lies as much with the professors themselves as with others. Faculties have failed to demand respect for their views and findings. The average faculty does not respect its own decrees. As Americans, I assume, our respect for law may be taken to be *nil,* but the intelligence of the all-wise faculty should dictate some respect at least for their own laws. But they have none. Oh, there are a few schools which have codified the rulings passed from time to time by the faculty, but in the great majority of cases no one in the school knows anything about past legislation. It might be found, possibly, by running through the faculty minutes of the past years, but who would be so foolish as to do that when it is so easy simply to "knock off" a new law whenever the need arises, and thus make the law *von Fall zu Fall,* as Bismarck made politics.

What the college "senate," as we sometimes proudly call the faculty, needs is a sense of dignity as a body, after the fashion of the original "senate" which wrote its own name first in the proud phrase *Senatus Populusque Romanus.* Far be it from the American college senate to write its name ahead of anything! This is the style it employs: *The Students, Administration, the Janitors and the Senate of So and So.* Most faculty men are too jealous of each other and of their "stand in" with the administration ever to pull together in anything that makes for strength in the faculty. Then there are, of course, the invertebrates and the weak whom ye have with ye alway; but that brings me to another chapter.

It is the chapter entitled: Scholarship not wanted in America! There are various reasons for this ukase which has gone forth. First, men of real scholarship might some time take it into their heads really to make the sons of fond parents study. Such old-fashioned notions would mean calamity—calamity to culture, because to get culture you must do nothing for at least four years. As the average small college has it: a four-years' loaf makes a well-bred man. Calamity to education for citizenship, for education for citizenship, as the cry is now penetrating to the small college, means, I fear: athletics, social intercourse, random talks by lawyers, politicians; a lot of frothy stuff about the glory and responsibility of citizenship, without the first idea of obedience to law and institutions, the very crown and cornerstone of good citizenship, without that most essential asset in the citizen; the power to do prolonged hard work.

And then it is fashionable to be in administrative work. Young men come to college asking for a course leading to the college presidency. Why not? The administrative officers are mentioned in the local paper oftener than any one else. The professor gets no notice unless it be the college green-goods man who sells intellectual gold bricks to the woman's club.

Consequence: Did you ever hear of a college fledgling whose supreme passion was to become a great scholar? Exhibit him, if you have, for he is a *rarissima avis* indeed. No, the premium is not on scholarship, as it is, for example, in the German universities. Thus it comes about that more and more rarely the really capable scholar does not go over to administrative work.

How shall we ever rear a race of scholars when there is neither pay nor honor in scholarship? The scant money compensation is patent, and honor is more than money to the idealist, and such, after all, the college professor is. There was a time when the highest ambition of every German youth was to be a poet. Why? Because two great world-poets were the most honored men in Germany. To-day it is different—every German youth burns to become a soldier, a politician—because these are the honored personages of the realm.

Who upholds scholarship as a great and valuable possession in America? Do we do it even in the colleges? In the smaller colleges the stimulus to scholarship is often wanting. The college library consists of some few thousand volumes of, in great part, antediluvian literature, presented perhaps by some alumnus of that early period, a few books for class readings, and a couple dozen journals. And should the faculty ask for more, the trustees answer them like they answered Oliver Twist: Why there's the *Encyclopedia Britannica* and the whole of the *World's Best Literature:* What more do you want, you snobs?

What shall Oliver do? Oh, occasionally a lively one works hard during vacations and at other times to get something done. But more often he chokes down his intellectual hunger, gets to tinkering with real estate, rubber stock, subsides into nocuous desuetude, and chews his little denominational cud. This brings me to chapter the last, which relates to Rousseau's dictum that a slave can not educate free men.

Students, especially immature ones, will imitate and model after their teachers. I am aware that the present plan of college studies, which, like a hotel dinner, gives you a lot of scraps, the whole not amounting to anything substantial, precludes a student's getting really interested in any branch of study or in any professor. Nevertheless, students will emulate their teachers. The greater the model now, the better for your boy and girl, and anything or anybody that undermines the respect, dignity and worth of the teacher, that makes him "unfree" is a drawback to education.

EDWARD WHYMPER: ALPINIST OF THE HEROIC AGE

By Professor B. E. YOUNG
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ON September 16, 1911, there died suddenly at Chamonix, France, a man who made a most unusual figure in his specialty. Most of us must have thought of Edward Whymper as long since dead and gone to the limbo of travelers, for he did his work a generation ago, reached his fame and enjoyed it, and had lately been forgotten, in the general commercialization of sports that has taken place in the last two decades.

Any one who has sojourned in the Alpine region for any length of time has been struck with the enormous number of tourists and sportsmen visiting this chief playground of the nations, and with the extraordinary perfection of the system of taking care of them and meeting their every whim. There are few centers, even the small ones, without their *Club Alpin.* It was not so when Whymper went to the Alps on a professional errand in 1860 and began his career as a climber.

By neither heredity nor environment did Whymper come by his mountaineering. Born in London, April 27, 1840, he was the son of an artist and engraver on wood, who gave him a good education at Clarendon House School and by private tutor, and then trained him carefully and with excellent results in his own profession. By 1860 young Whymper had become an artist of sufficient ability to be sent to Switzerland by a London publisher to make some sketches of the great Alpine peaks, and more particularly to prepare some illustrations which were intended to celebrate the triumph of an English party, headed by Professor Bonney, who intended to make the ascent of Mont Pelvoux in Dauphiny. Whymper states that at this time he had only a literary acquaintance with mountaineering, and had not even seen, much less set foot upon, a mountain. The party of distinguished Englishmen failed in their attempt to conquer this virgin mountain. A very agreeable Frenchman, who accompanied the party, was charmed with Whymper, and begged him to return with him to the assault. In 1861 he did so, and with his friend made the first ascent of Mont Pelvoux; thus was he infected with the love of high places!

In 1861, Edward Whymper found in the Alps none of the modern machinery of mountaineering; there were no railroads to the top of Jungfrau; no railings on the Matterhorn and no hotels on the Mer de Glace; travel was slow, mostly on foot, or by the unreliable diligence,

which took a traveler only to the foot of the lower valleys. Although De Saussure, the Swiss pioneer, had done his work on Mont Blanc as early as 1787, he had had so few successors that he seemed almost a contemporary. Professional guides were few, not especially experienced or adventurous when new territory was contemplated, so that we must not be astonished to find that Whymper, Tyndall, Forbes, Kennedy, Sir Alfred Wills, Sir Leslie Stephen sometimes dispensed with guides or used them more as porters or servants than as advisers.

It was the heroic age of Alpinism. The vast flood of development and facilitation—vulgarization, let us say—did not come until the seventies or eighties. Almost every ascent was a geographical achievement, accomplished by the bitterest toil. The early sixties were a school in which were educated some of the great climbers and explorers of the nineteenth century.

Having learned his first lesson on the Pelvoux, Whymper dallied for no further lessons, but attacked the Matterhorn at once, in his vacation of 1861. The Matterhorn was then the last great Alpine peak that remained unscaled; less on account of the difficulty of the feat than by the doubt inspired by the invincible appearance of the mountain. It was regarded with terror by the climbers and with affrighted superstition by the natives. Even to-day it is dreadfully impressive to the casual tourist; it never seems commonplace and stands almost alone among mountains. It still has no rivals in the Alps for difficulty, and but few in the world.

To-day it is curious to read of Whymper's fruitless searchings here and there to find guides for the Matterhorn. There was apparently only one man in the Swiss valleys who believed that the mountain *could* be ascended, and that was Jean-Antoine Carrel, destined later to become the most famous of guides. With him Whymper made his first attack upon the peak, in August, 1861. One other guide, J.-J. Carrel, accompanied them. They failed, but learned valuable lessons. Similar attempts were made in 1862 and 1863 without success, but all the time Whymper was making marvelous progress as a scientific mountaineer.

Whymper's impatience with his guides led him in 1862 to make another attempt on the mountain alone. Many of us read in our first readers the story of his solitary scramble on the Col du Lion, terminating in a terrific fall down an ice slope. Here he was saved only by a hair from a fall on to the Glacier du Lion, a thousand feet below. This early experience seems to have been a valuable one for him.

In 1864 Whymper turned aside from the Matterhorn to make what seems to the writer one of his chief feats—the ascent of the Pointe des Écrins. This is the highest of the French Alps, and in 1864 was still unconquered. It is an exceedingly steep and smooth tooth of rock.

It was one of the severest climbs that Whymper ever had in his career, full of peril and physical suffering. The party reached the summit by the glacier of the Ancula. Read again Whymper's description of this glacier:

> Imagine a triangular plane 700 or 800 feet high, set at an angle exceeding 50 degrees; let it be smooth, glassy; let the uppermost edges be cut into spikes and teeth, and let them be bent some one way, some another. Let the glassy face be covered with minute fragments of rock, scarcely attached, but varnished with ice. Imagine this, and then you will have a very faint idea of the face of the Ecrins, on which we stood. It was not possible to avoid detaching stones, which, as they fell, caused words unmentionable to rise. The greatest friends would have reviled each other in such a situation.

A few days afterward he climbed the Aiguille Verte, a considerable feat in itself, though Whymper, in his modesty, makes little of it. This was the first of the great Chamonix Aiguilles to be ascended.

It was not until his eighth attempt on the 13th of July, 1865, that Whymper finally attained the summit of the Matterhorn. He left Zermatt at 5:30 in the morning with three guides, Michel-Auguste Croz, whom Whymper loved as a brother, old Peter and young Peter Taugwalder, Lord Francis Douglas, the Rev. Charles Hudson and Mr. Hadow, a young man of nineteen. After long study, Whymper had rejected the usual route up the Matterhorn by the southwest or Italian ridge. Professor John Tyndall and he, in their fruitless emulation of each other, had stuck to this traditional route. Mr. Whymper now determined to try the eastern face, convinced, as he says, that its almost perpendicular appearance from Zermatt was an optical illusion and that the dip of the strata, which on the Italian side formed a continuous series of over-hangs—"ghastly precipices"—on the opposite side would become a great natural staircase with steps inclining inward. This apparently trivial deduction was the key to the ascent of the Matterhorn, and this route has since become the usual one.

All readers of adventure are familiar with this ascent. Sleeping over-night on the mountain, they reached the summit, with severe rock-work just before the finish. On the descent, however, came what is perhaps the most sensational accident, everything considered, in the history of mountain climbing. Let us quote Whymper's own words:

> A few minutes later (that is, just after the descent was undertaken) a sharp-eyed lad ran into the Monte Rosa Hotel (at Zermatt), saying that he had seen an avalanche fall from the summit of the Matterhorn on to the Matter-horngletscher. The boy was reproved for telling idle stories: he was right, nevertheless, and this was what he saw. Michel Croz had laid aside his axe, and in order to give Mr. Hadow greater security was absolutely taking hold of his legs and putting his feet, one by one, into their proper positions. As far as I know, no one was actually descending. I can not speak with certainty, because the two leading men were partially hidden from my sight by an intervening

mass of rock, but it is my belief from the movements of their shoulders, that Croz, having done as I have said, was in the act of turning round to go down a step or two himself; at this moment Mr. Hadow slipped, fell against him and knocked him over. I heard one startled exclamation from Croz, then saw him and Mr. Hadow flying downward: in another moment Hudson was dragged from his steps, and Lord F. Douglas immediately after him. All this was the work of a moment. Immediately we heard Croz's exclamation, old Peter and I planted ourselves as firmly as the rocks would permit: the rope was taut between us, and the jerk came on us both as on one man. We held, but the rope broke midway between Taugwalder and Lord Francis Douglas. For a few seconds we saw our unfortunate companions sliding downward on their backs, and spreading out their hands, endeavoring to save themselves. They passed from our sight uninjured, disappeared one by one, and fell from precipice to precipice on to the Matterhorngletscher below, a distance of nearly four thousand feet in height. From the moment the rope broke it was impossible to help them. So perished our comrades.

Only Whymper and two of the guides were saved by the breaking of the rope.

For the space of half an hour we remained on the spot without moving a single step. The two men, paralyzed by terror, cried like infants. . . . Old Peter rent the air with exclamations of "Chamonix! Oh, what will Chamonix say?" He meant, "Who would believe that Croz could fall?" The young man did nothing but scream or sob, "We are lost! we are lost!" Fixed between the two I could neither move up nor down.

It was hours afterward before they descended the mountain and some days before the bodies of three of the unfortunates were rescued; that of Lord Francis Douglas was never found. Some day, perhaps, it will come forth fresh and life-like from the foot of the glacier.

Such were the difficulties of Alpine climbing in 1865. Scarcely can we realize to-day what an achievement this was. Says Javelle in his "Souvenirs d'un Alpiniste":

After the first ascent of Mont Blanc and until that of Everest the most *beautiful* conquest of the climbers is certainly the Matterhorn.

Besides his own trials, Whymper describes seven other well-organized attempts to scale the mountain that had been made during the half-dozen years preceding his achievement. The fearful cold, snow storms and almost cyclonic winds of the upper reaches, contributed to the discomfiture of these earlier parties. One might add that while these other climbers were fine, bold mountaineers, they lacked the extraordinary preparedness and resourcefulness, amounting almost to luck, of Edward Whymper.

It may be said that this ascent made little direct contribution to the sum of knowledge. It did have the effect, however, of awakening a widespread interest in the Alps. Of course, the terrible accident contributed not a little to this result. The next few years witnessed the

outburst of British energy, which brought the subjugation of all the higher Alps, until the ascent of the Meije in 1877. This was the last great Alpine peak to be conquered. From the pioneering of Whymper and his brethren came the widespread efforts which have left only a few great summits on the globe still unconquered.

These and other achievements of Mr. Whymper in the Alps are set forth in his famous book, "Scrambles among the Alps in the Years 1860–1869." The beautiful illustrations were engraved by the author himself, and they have been copied numerous times in books of travel. This absorbingly interesting little volume now commands a premium among collectors. It is at once a thrilling tale for children about the family fireside; a guide-book for the amateur; a style book for the writer of travels. Forty years have improved its flavor but have not dimmed its charm or usefulness.

Whymper returned to England to find himself grown famous in a night. The sad fatalities of his expedition did not shake his nerve. He was soon on the road again, this time visiting Greenland on an important expedition in 1867. The fine collection of fossil plants and Eskimo relics which he made on this occasion and upon a later visit in 1872, are now preserved in the British Museum. He also proved, by the discovery of magnolia cones, that Greenland was once covered by luxurious vegetation. His able review of this work was published in the *Report* of the British Association for the year 1869. Though the Greenland expedition was not the success that Whymper hoped it would be, for he was hampered by lack of financial backing and by the prevalence of an epidemic among the natives, yet he not only made important researches in the fauna and flora of Greenland, but he proved that the interior could be explored by the use of properly constructed sledges, and thus contributed to the advance of Arctic exploration and to the ultimate discovery of the pole. The expedition of 1872 was devoted to a survey of coast line. Although a busy artist, he found sufficient vacation every year to do some valuable climbing or exploration.

It was in 1879 that Whymper undertook his notable journey to the Ecuadorian Andes. He had contemplated going to the Himalayas, and in 1874 had projected a scheme which would have taken him to this, probably the most difficult mountaineering ground on the globe. He proposed to carry his exploration and research up to the highest attainable limits. Just at the time it was possible to start, the British Government entered upon the construction of a "scientific frontier" for India, and rendered that region unhealthy for any but soldiers. Whymper then turned to South America. Perhaps he would have preferred to go to Peru or Chile, but owing to unhappy local dissensions

he turned to the Republic of Ecuador, the most lofty country which remained accessible.

Since his achievements in the Alps he had turned more and more toward the scientific side of mountaineering. The main objects of his South American journey were to observe the effects on the human body of low pressure and to attain the greatest possible height in order to experience it; to determine the relative altitudes and positions of the chief mountains of Ecuador; to make comparison of boiling-point observations and of the aneroid barometer against the mercurial barometer; and to make collections in botany, zoology and geology at great heights. He concerned himself neither with commerce nor politics, nor with the natives and their curious ways, except incidentally.

He had not the means to project a great scientific expedition; his staff was modest, consisting of his old Alpine guide, Jean-Antoine Carrel; a cousin, Louis Carrel, with a third man picked up in Ecuador. Landing at Guayaquil on December 9, 1879, he proceeded at once up the Guayas River to Bodegas, and thence to the plateaus of the great extinct volcano Chimborazo. After a careful examination of the mountain—referring to the accounts of Humboldt in 1802 and Boussingault in 1831, from which he did not, after all, receive much aid—he attacked the mountain on December 27. On December 28 he and his two European guides were stricken with mountain-sickness for the first time, with intense headache, feverishness and disturbance of respiration. Fighting this off and triumphing over constant delays due to inefficient help, he finally reached the top of Chimborazo on January 4, 1880. On this ascent he took constant readings of the barometer and thermometer, and of the variations of the weather. He fixed the height of the summit at 20,545 feet. This is all set forth in the most interesting fashion in his "Travels Amongst the Great Andes of the Equator," New York, 1892.

Whymper met few of the greater perils of mountain-climbing in Ecuador that he had suffered in the Alps. He suffered more from annoyances, such as snow-blindness, frost-bites, inefficiency and thievery on the part of the natives, almost incredible sanitary conditions in the inns and tambos. All his party developed complaints of one kind and another.

From Chimborazo he went on to the conquest of Corazon, Cotopaxi—where he spent the night on the cinder cone in the very edge of the crater—Illiniza, Sincholagua, Antisana, Cayambe, Sara-Urca and others. His description of the sojourn on Cotopaxi makes thrilling reading. His own beautiful engravings add great interest to this account.

Whymper enjoyed adventures when they came, but above all he

tried to make this visit a scientific one. He secured extremely valuable collections of the earthworms, beetles, centipedes, dragon-flies, butterflies, ants, moths, scorpions, crustacea and the ferns and lichens of the greatest altitudes. He was a man who knew just what was worth collecting, and brought back numerous totally new species. He was able also to collect quite a number of unusual ornaments, weapons and implements made by the tribes of prehistoric days, and choice specimens of volcanic rocks and dust. He had the good fortune to be on the top of a near-by mountain at the time of an eruption of Cotopaxi; he saw its very beginning and observed its progress; and has left us admirable notes of the phenomena.

His observations on mountain-sickness led him to conclude that it was caused by diminution in atmospheric pressure, operating in at least two ways: by lessening the value of the air that can be inspired in any given time, and by causing the air or gas within the body to expand and to press upon the internal organs. In the second case, the effects may be temporary and pass away when equilibrium has been restored between the internal and external pressure.

The publication of his work on Ecuador was recognized by the Royal Geographical Society, which made him a fellow, and gave him the "Patron's Medal." The Royal Society of Edinburgh made him a fellow and the Italian King made him a Knight of the Order of St. Maurice and St. Lazare. Honorary memberships in geographical and mountain-climbing clubs of Europe and America were thrust upon him.

His experiences in South America convinced him that the aneroid barometer was unreliable at high altitudes, and he published a work on "How to Use the Aneroid Barometer," 1891, and succeeded in causing important improvements in the construction of this instrument.

His extensive observations of glaciers led him to attack those who claimed for glaciers great powers of erosion. He considered them of secondary importance to the great forces of expansion and contraction in the breaking-down of rock structures of the mountains. He conceded that glaciers carried down large quantities of material, but would not concede that they created much of this material. Everywhere he went he set down interesting geological observations.

Whymper's reputation as a mountaineer put him in demand for articles on the Alps. In 1896, at the instance of John Murray, the London publisher, he gathered a great quantity of information into a "Guide-book to Chamonix and Mont Blanc" (206 pp.). This book soon became the standard of its kind. It has had an immense sale, reaching its fifteenth edition in 1910. In 1897 Murray brought out Whymper's "Guide Book to Zermatt and the Matterhorn," which is, if

anything, a still more ambitious work in two hundred and twenty-four pages, profusely illustrated, and filled with the most interesting and advantageous information. In 1911 this also attained its fifteenth edition. The same scientific spirit that made his earlier books so attractive and reliable is inevitably present even in a popular guide book.

The oncoming of old age did not retire Whymper to a chimney corner. In 1901 he made an exploring expedition in the Great Divide of the Canadian Rockies. He repeated this visit four times, also pushing on to the Selkirk Mountains.

We have no record that he ever undertook a voyage to the Himalayas after his disappointment in 1874. It is significant that his death took place at Chamonix. It may be that, feeling the approach of dissolution, and unwilling to die in his bed, he was about to undertake another ascent of Mont Blanc, "the great White Mountain" of which he never grew tired.

Edward Whymper was not a transcendentalist or an esoteric in mountain climbing. He employed his best descriptive talents and his charming humor of the best British variety in his descriptions; he knew the mountains in their secret moods; but he seldom broke out into poetry. There is no record of revelry by night, or of singing Alpine pæans before breakfast. He seems to have gone about mountain climbing seriously, yet pleasantly withal. No dangers affrighted him, but, on the other hand, he did not seek extraordinary gymnastic feats. It is safe to say that he had ingrained in him true love for the mountains, and a great delight in the views from above the clouds, but he was also imbued with the savage lust of exploration and pioneering.

We may live to see a school of climbers that may accomplish more things than his, but we shall not see one of more heroic spirit.

The world owes him something more than a reputation of an undaunted climber of mountains or a fame that can be assessed in worldly terms. Zermatt owes him a statue, no less than Chamonix owed to De Saussure and Balmat.

ALCOLOL FROM A SCIENTIFIC POINT OF VIEW

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SOME problems permit of a ready and satisfactory solution with but little difficulty, while in fullness others remain obscure for generation upon generation, being resolved slowly and at great pains. In the latter class stand the problems involved in the study of alcohol. Some of these, although investigated for centuries, have been but recently solved or are still in the process of solution. Other associated problems remain which are but little better understood to-day than they were in the time of Aristotle.

Of this group of problems, solved or in the process of solution, I should like to consider in order the following parts:

Alcohol: I. Its Discovery and Nature.
II. The Relative Toxicity of the Various Alcohols.
III. The Destiny of Alcohol in the Body.
IV. The Action of Ethyl Alcohol on the Body and on its Output of Physical and Mental Work.

I. The Discovery and Nature of Alcohol

Through many ages nature has been elaborating a substance which has come to affect human progress most profoundly. This substance we to-day call alcohol. Although the existence of alcohol was surmised almost four centuries before the Christian era, yet practically twelve centuries intervened before its extraction, and ten centuries more elapsed before its nature and the biological significance of its origin were fully made out.

To appreciate the conditions confronting men who attacked problems of the sort in the infancy of science, we should look back to those ages in which natural phenomena called forth extravagant explanations, a day when apparatus and laboratories were unknown and, above all, a time when the scientific momentum, which is ours because they labored, was yet unborn. Under such conditions the work on alcohol was begun.

Alcohol Early Detected in Wine

Two important observations were early made concerning wine. The first of these was that wine, unlike water, if thrown into the fire emits a flame. When questioned as to the cause of the phenomenon Aristotle answered that the flame was due to an exhalation contained in the wine. Later, Pliny related that the wine from Falernus Ager blazed up at the contact of a flame—a wine, as Berthelot remarks, evidently rich in inflammable exhalation.

Since men of that period knew that sea water vaporized and con-

densed was drinkable, we might expect that it was but a step to the extraction of the inflammable exhalation. But a long step it proved to be! An attempt at condensation was in fact made at that time with the result that wine upon evaporation became water.

It was not until the fourth century of the Christian era that an adequate distilling apparatus was perfected; and this, although used in the distilling of various substances, seems not to have been employed for the production of alcohol. Not until the writings of Marcus Græcus, in fact (twelfth or thirteenth century),[1] do we get unmistakable evidence of the distillation of alcohol—the distillate obtained being called "aqua ardens."

An explicit account of the process of distillation and a description of the characteristics of the alcohol thus obtained occur in a Latin manuscript published about 1438—but which according to Berthelot contained older excerpts. In this the preparation of alcohol is described as follows:

> Take good old wine, any color; distil it over a slow fire (in a still and an alambic closely joined). The product of distillation is called "aqua ardens."

To "aqua ardens" are ascribed the following characteristics which we to-day associate with alcohol.

> Moisten a linen cloth in it, and light it. It will produce a great flame; when it has gone out the cloth will remain intact. If you put your finger in this aqua (ardens) and light it, it will burn like a candle without causing injury. If you put a lighted candle in it the candle will not be extinguished.

Thus from the time of Aristotle to the period immediately following that of Marcus Græcus there elapsed an interval of considerably more than a thousand years in which through extended effort, the exhalation of wine was eventually obtained. As time passed methods were devised by which aqua ardens was procured in greater concentration. It should be stated, however, that the word "alcohol" as applying to present-day alcohol was not used until the sixteenth century and further that alcohol in the purity in which it is now obtained is a product of the century just passed.

The second of the early discoveries made in the study of wine was that of its stimulating effect on man. An interpretation of this effect in later years greatly influenced the use of alcohol. Prominent in this interpretation stands the name of Arnaldo de Villaneuva. In his work entitled "The Conservation of Youth" (1309) after speaking of the delicacy of the nature of the spirit of wine, and enumerating the various maladies cured by it, he adds that the spirit of wine should be called "eau de vie,"[2] for it prolongs life.

From the time of Arnaldo de Villaneuva to the present there has been growing a counter belief in the minds of many that the prolongation of life is not one of the characteristics to be associated with "eau

[1] Some give the date of Marcus Græcus in the eighth century.

[2] Eau de vie—The elixir of life.

de vie." Indeed, some believe that "eau de vie" curtails rather than prolongs life, and some there are who go so far as to maintain that "eau de vie" should be called "eau de mort."[3] But this is aside from the subject! It is of interest, however, to note that out of the opinion expressed by Arnaldo de Villaneuva probably grew the prevailing belief in Europe in the efficacy of the daily use of brandy, and to the latter may be attributed the custom of the mint julep or so-called old-age drink prevalent in parts of our own south.

Alcohol Discovered in Substances other than Wine

Man, seeking ways of producing alcohol from substances other than wine, early made the important observation that fermentation and the production of alcoholic liquids go hand in hand. This discovery, as time passed, became common knowledge, with the result that fermented liquids from different sources came to be looked upon as characteristic national drinks—thus in France *wine* from grapes, in Jamaica *rum* from cane, in Russia *vodka* from rye, in Japan *saki* from rice, in Germany *beer* from barley and in America *whiskey* from Indian corn.

But some substances long used in the formation of alcohol, unlike the juice of grapes, are themselves unfermentable. Some of these we shall consider more in detail.

Common or cane sugar, although of itself incapable of undergoing alcoholic fermentation, by the action of a ferment invertase, takes up a molecule of water, splitting into glucose and fructose, both of which are fermentable. Thus cane sugar, $C_{12}H_{22}O_{11} + H_2O$, becomes $C_6H_{12}O_6$ (glucose) and $C_6H_{12}O_6$ (fructose). From the fermentation of glucose and fructose alcohol results.

The starch of cereal grains when converted into *fermentable sugar* likewise becomes an effective source for alcoholic fermentation. It has long been known that a starch paste, to which malt or malt extract (containing diastase) has been added, becomes transformed into a sugar maltose. Now maltose itself is not subject to alcoholic fermentation, and so it must be acted upon by another ferment, maltase. This converts the maltose into dextrose and glucose, the latter of which we have seen to be produced in the case of cane sugar.

In 1837 Cahours employed potatoes as a source for alcoholic fermentation. The starch of potatoes is insoluble in cold water, but upon heating it in the presence of dilute sulphuric acid the starch is converted into fermentable sugar. In this process in addition to the ethyl alcohol produced a considerable amount of one of the higher alcohols, amyl alcohol, was discovered.

Two years earlier than the discovery of amyl alcohol another alcohol was obtained. This was produced not by fermentation, but by the destructive distillation of wood, and was therefore called wood or methyl alcohol.

[3] To be seen on the walls of one of the well-known sanatoria of France.

This alcohol is obtained by distilling the wood in iron retorts at a high temperature (about five hundred degrees C.). The vapors thus driven off when condensed are found to contain, in addition to a large percentage of methyl or wood spirit, acetone, acetic acid, etc. Upon being freed from these foreign substances methyl alcohol is obtained in purity.

Concentration and Purification of Alcohol

The alcohol obtained at the time of Marcus Græcus contained a relatively large amount of water and in addition numerous foreign substances. To remove these was the task set for succeeding workers. It was found that the percentage of aqua ardens could be perceptibly raised if the alcohol collected be redistilled. If the process of redistillation be repeated a number of times, a concentration approximating 90 to 95 per cent. was possible.

In the present-day commercial manufacture of alcohol the apparatus has been so perfected that by a single distillation an equally high percentage is obtainable.

By neither of these methods, however, is it possible to render alcohol anhydrous, or free from water. But alcohol of a relatively high percentage placed in contact with a chemical, such as caustic lime or baryta having a strong affinity for water, and then redistilled may be rendered practically free from water.

The foreign substances present in the alcohol were found to be principally glycerin, succinic acid and higher alcohols, traces of several of the latter, such, for example, as propyl, butyl and amyl alcohol, being found in ethyl alcohol.

To separate amyl alcohol from ethyl it is necessary to employ a physical property which in the different alcohols is perceptibly different —that is, the boiling points. While ethyl boils at 78.4° C., propyl at 97° and butyl at 117°, amyl does not reach its point of ebullition until it is elevated to a temperature of 132° C.

It would therefore appear that the separation of amyl alcohol from ethyl would be easily effected by raising the temperature of the mixture to 78.4° C. and thus driving off the ethyl alcohol. This is in fact the method used, but it is found that while the first part of the distillate is largely ethyl, later amyl is also given off at a temperature far below its boiling point. In a word a single distillation is by no means sufficient to separate the two. By a process known as fractional distillation, it has been found (Roscoe and Schorlemmer) that when a temperature of 80 to 90° C. is employed 88.1 per cent. of ethyl alcohol is distilled off and that 11.9 per cent. of amyl also passes over. In the case when the temperature is raised from 131 to 132° C. 0.2 per cent. of ethyl is still obtained and 99.8 per cent. of amyl.

Since the boiling points of propyl and butyl alcohol approximate

more nearly that of ethyl, it is practically impossible, even by repeated fractional distillation, to remove *all* traces of these.

The alcohols with a higher boiling point are also found to differ from ethyl alcohol in another respect—that is, in their chemical form or molecular weight. The molecular weight of ethyl alcohol taken as a standard is 46; that of propyl, 60; that of butyl, 74; and that of amyl, 88. It is thus seen that in both molecular weight and boiling point, alcohols of fermentation fall into a regular series ascending from ethyl to amyl.

In addition to the above alcohols of fermentation is wood or methyl alcohol which reaches its boiling point at only 66° C. (or 66.5°) and has a molecular weight of 32.

The molecular weights and boiling points found for the primary alcohols named may be briefly summarized as follows:

Alcohol	Molecular Weight	Boiling Point
Methyl	32	66.0° C.
Ethyl	46	78.4° C.
Propyl	60	97.0° C.
Butyl	74	117.0° C.
Amyl	88	132.0° C.

The Biological Significance of Fermentation

While the production of alcohol has long been associated in the minds of all peoples with the process of fermentation, yet the exact nature of the process was unknown until the significant work of Pasteur appeared. Pasteur in his work on fermentation, as in all his work, was unwilling to accept blindly an interpretation of the meaning of the process until he had examined in detail and elucidated step by step the actual occurrences taking place.

By taking the juice of the grape he observed, as had often been observed before, that upon leaving it for a time at a warm temperature, bubbles of gas arose. This gas was evidently the result of a chemical process going on within the mixture. But to Pasteur is due the credit of showing for the first time that within the mass of grape juice the thousands of living organisms (which Latour, Schwann and others had already seen) were busily engaged in the process of digesting a part of the sugar contained in the juice. Pasteur believed that these living organisms, by taking oxygen from the sugar, caused the splitting up of the sugar into two substances. One of these he had seen arising as bubbles of gas—carbon dioxide—the other remained in the mixture, gradually increasing in strength as more and more was produced. The latter substance Aristotle had spoken of as the exhalation of wine. Marcus Græcus denominated it aqua ardens. We call it alcohol. The organisms which thus produce alcohol are the yeasts, many kinds of which are now known.

To Pasteur fermentation was life without air. That is, the yeasts

living in a liquid medium in order to secure sufficient oxygen procured it from the sugar, thus, as we have said, producing from the latter CO_2 and alcohol. The production of alcohol hence resulted as a product of metabolism in the body of a living organism.

It has been more recently shown, however, that the active cause of fermentation is to be found not in the yeast itself, but in a ferment (or enzyme) produced by the yeast cell. This ferment Buchner has succeeded in freeing from the cell, so that it is now possible to produce alcoholic fermentation without the presence of the living yeast.

But this discovery does not detract from the work of Pasteur, to whom is due the great credit of definitely showing the importance of living organisms, the yeasts, in the production of alcohol, since without the yeast cell the ferment or enzyme would not be produced.

The nature of the experiments by which Pasteur demonstrated the importance of the yeast is of interest. In the first place he showed that grape juice filtered and kept from contact with the air is not subject to alcoholic fermentation. In the second case he demonstrated that grape juice sterilized by heat is, if similarly protected, unfermentable. In the third case he showed that if the yeasts caught on the filter used in the first series of experiments be added to the sterile juice of the second series, fermentation ensued.

Pasteur was asked the origin of the yeasts which make the alcohol in wine. The question was answered by an experiment. Taking the grapes and completely removing from them the fuzz or "bloom," he extracted the juice free from contact with the air. No fermentation followed, consequently no alcohol resulted. From this it was learned that the yeasts necessary for the production of the alcohol of wine live in nature in the air and are found in abundance on the outside of the grape. If the grapes be crushed the sweet juices serve as food for the yeast plants. These when well fed grow rapidly and, by a simple process of budding, produce myriads of yeast plants. These, like their parents, give rise to ferments which break down the sugar into CO_2 and alcohol.

It was later found that although these yeasts may increase greatly in numbers, a strong percentage of alcohol is impossible in nature. This is due to the singular fact that when the strength of alcohol increases perceptibly the organisms forming it are unable to thrive in their own product. Hence they increase more slowly. When a strength of 12 per cent. of alcohol is reached reproduction is manifestly checked, and at 14 per cent. all cell activity ceases.

To increase the strength and purity of the alcohol thus formed in nature, man, as we have seen, has resorted to the processes of distillation and rectification by which alcohols practically free from impurities may be obtained in concentration.

THE BIOLOGICAL STATUS AND SOCIAL WORTH OF THE MULATTO

By Professor H. E. JORDAN, Ph.D.
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THE United States has something more than a "negro problem"; it has a mulatto problem. Our 10,000,000 colored fellow-citizens comprise somewhat less than 8,000,000 full-blooded negroes; approximately 2,000,000 contain varying percentages of "white" blood. This "white man's burden" has several cardinal aspects, notably, social, economic and political. The fundamental aspect, however, is the biologic. Does the presence of this vast company of "half-breeds" complicate or facilitate the "problem"? Certain it is that they must be reckoned with. Are they an aid or a hindrance to a permanent satisfactory adjustment of full relationship between the white race and the colored? To one man their presence is a source of black despair, to another of radiant hope. Which is the more rational attitude? It depends upon the scientific facts in the case. The first point concerns the biological status of this mulatto hybrid.

It may help the subsequent discussion to note at this point the fact that Jamaica does not have a "negro problem" as we know it in the United States. And on the face of things it would appear that it might well be present there in even more aggravated form. For in Jamaica there are only about 15,000 whites among a colored population of about 700,000, including about 50,000 mulattoes. It should be noted that in this "Queen of the Greater Antilles" the mulattoes, as a class, are more nearly at the level of the whites than at that of the pure negroes. The mulattoes contribute the artisans, the teachers, the business and professional men. They are the very backbone of wonderful Jamaica. To be sure, Jamaica has had 30 years more than the United States during which to "solve" her "negro problem." But perhaps the perfect adjustment between the races in Jamaica and the elimination of any "problem" of this kind finds its explanation in a more rational and more consistent political treatment made possible by the absence of any constitutional prescription. We may well suspect that the inconsistency of according to the negro legal (constitutional) equality and withholding it practically (politically and socially) has had a morally harmful effect upon both black and white. To stultify oneself as between one's theory and practise is always subversive of high moral tone. We shall return to this point below.

Suffice it to note here that the Honorable Mr. Olivier, governor of Jamaica, recognizes in the presence of the mulatto only a past blessing, a present advantage, and a future promise of great good.

In the beginning we shall need to raise the question once more as to whether the Negro and Caucasian are actually different man-species, as was held by the eminent zoologist, Louis Agassiz, and as is still held by many, as, for example, the noted French psychologist, Le Bon; or whether they simply represent different "races" or varieties of the same species *homo,* as is more commonly believed. Le Bon quotes with approval:

> If the Negro and the Caucasian were snails, all zoologists would affirm unanimously that they constitute excellent species, which could never have descended from the same couple from which they had gradually come to differ.[1]

However, simply external gross appearance is no infallible criterion by which to judge of species. And the more highly developed the organism the wider do the individuals differ within the species. Two human brothers may differ infinitely more than two true snail-species. Zoology can furnish many examples where a larval form, or individuals of opposite sex, or the same form modified by peculiar environmental conditions, have been mistaken for separate species. The real scientific test is that of impossibility of effecting a cross, or of infertility *inter se* of hybrids of a possible cross. A cross between the horse and the ass produces a mule. But mules are infertile if interbred. Hence horse and ass are separate species. A very valuable cross can also be effected between the cow and the buffalo. But the offspring are barren bred among themselves. Hence cow and buffalo are at least of different species. The mulatto is the product of a negro-white cross. He is as fecund with his own kind, or when he mates with white or negro, as either pure-breeding negroes or whites are. As a matter of fact, the mulatto is probably more prolific than the normal average of either white or negro. During the past twenty years he has increased at twice the rate of the Negro. The Negro is then simply a black variety of the human species. He is the white man's brother; and we may both be cousins of the apes.

The second question that presents itself is this: Is the mulatto necessarily degenerate? The idea has been and is very eminently and widely held that the crossing of races is intrinsically bad, biologically harmful; that it inevitably and inexorably works deterioration. Agassiz noted in Brazil a

> decadence that results from cross-breeding which goes on in this country to a greater extent than elsewhere. This cross-breeding is fatal to the best qualities whether of the white man, the black, or the Indian, and produces an indescribable type whose physical and mental energy suffers.

[1] "The Psychology of Peoples," New York, 1912, p. 4.

Humboldt and Darwin held the same opinion. Hilaire Belloc in "The French Revolution" notes regarding Marat

> Some say . . . that a mixture of racial types produced in him a perpetual physical disturbance: his face was certainly distorted and ill-balanced (p. 78).

Schultz claims to have noted an intrinsic deterioration in Gentile-Jew crosses. Le Bon expresses himself as follows:

> To cross two peoples is to change simultaneously both their physical constitution and their mental constitution . . . the first effect of interbreeding between different races is to destroy the soul of the race, and by their soul we mean that congeries of common ideas and sentiments which make the strength of people, and without which there is no such thing as a nation or a fatherland . . . a people may sustain many losses, may be overtaken by many catastrophes, and yet recover from the ordeal, but it has lost everything and is past recovery, when it has lost its soul (pp. 53–55).

Le Bon explains this supposed necessary degeneration in half-breeds as due to the "influence of contrary heredities" which "saps their morality and character." We shall return to Le Bon's idea of a loss of "soul" as consequent of inter-racial crosses.

This same idea of necessary degeneracy in cross breeds is the main motive of much opposition to foreign immigration. We shall see that this is the very least element of danger; in fact, it may be a real panacea to other actual evils of immigration, otherwise (*i. e.,* without neutralization through cross-breeding) a serious menace. Note here the superb products of the English, German, Dutch, French and Spanish crosses of late and post-colonial days. The superiority of especially the English-German crosses, very generally noted, finds its reason in the initial superiority of the crossing stocks. And this is the secret of the entire matter. Offspring take after their parents, whether these be of the same or different race. The production of the Boer race, one of well-marked physical and mental characteristics, notwithstanding that it is of mongrel immigration, Dutch, French, and in some degree, British, is sufficient disproof of inherent hurt in inter-racial crosses. The more progressive of "white" nations have been produced by European interbreedings, for example, the English and the Bulgars. Furthermore, Davenport reminds us of probably even Ethiopian contributions to our European stock, "when we stop to consider the slaves, not only white and yellow, but also brown and black, that were brought to Rome, became free there and contributed elements to the population of Italy and to all Europe." Indeed, this may well have been a partial source of the pigment of European brunets.

Thoroughbred parents produce similar progeny. Inferior or degenerate parents have only defective children. In proof of which the following: Probably the most brilliant student I have ever known is the son of a high-class Chinese woman by an American missionary. There is probably as great a difference, from a general anatomical viewpoint,

exclusive of skin-pigment, between a Chinese and Caucasian as between a Negro and Caucasian. Similarly with respect to a number of Caucasian-Japanese crosses. There is no instinctive revulsion against such alliance; hence they are frequently made by superior individuals; and the offspring are of the same superior type, without evidence of deterioration. Indeed, it frequently happens that an unusually fortunate combination of the best racial characteristics of both races appears in an offspring of such cross, resulting in an extraordinarily endowed human being.

I admit the general inferiority of black-white offspring. Defective half-breeds are too prevalent and obtruding to permit denying the apparently predetermined result of such crosses. But I emphatically deny that the result is inherent in the simple fact of cross-breeding. There are not a few very striking exceptions among my own acquaintances. Absolutely the best mulatto family I have ever known traces its ancestry back on both the maternal and paternal side to high-grade white grandfathers and pure-type negro grandmothers. The reason for the frequently inferior product of such crosses is that the better elements of both races under ordinary conditions of easy mating with their own type feel an instinctive repugnance to intermarriage. Under these usual circumstances a white man who stoops to mating with a colored woman, or a colored woman who will accept a white man, are already of quite inferior type. One would not expect superior offspring from such parents, if it concerned horses or dogs. Why should we expect the biologically impossible in the case of man? If the parents are of good type, so will be the offspring. And even with the handicap of frequently degraded white ancestry, the mulatto of our country, as in Jamaica, forms the most intelligent and potentially useful element of our colored population.

The fact then is established, beyond all possibility of disproof, it seems to me, that a negro-white cross does not inherently mean degeneracy; and that the mulatto, measured by present-day standards of Caucasian civilization, from economic and civic standpoints, is an advance upon a pure negro. In further support of the potency of even a relatively remote white ancestry may be cited the almost unique instance of the Moses of the colored race, Booker T. Washington. As one mingles day by day with colored people of all grades and shades, one is impressed with the significance of even small admixtures of Caucasian blood. What elements of hope or menace lie hidden in these mulatto millions? How can they help to solve or confuse the "problem"?

Let us see clearly what we are dealing with. What are the large distinctive characteristics of the three types, white, mulatto and black, forming our civic and social complex? As to the negro—I quote from Le Bon:

Above the primitive races are found the inferior races, represented more especially by the negroes. They are capable of attaining to the rudiments of civilization, but to the rudiments only. They have never been able to get beyond quite barbarian forms of civilization, even where chance has made them the heirs, as in Saint Domingo, of superior civilization. . . . The inferior races further display but an infinitesimal power of attention and reflection; they possess the spirit of imitation in a high degree, the habit of drawing inaccurate general conditions from particular cases, a feeble capacity for observation and for deriving useful results from their observations, an extreme mobility of character, and a very notable lack of foresight. The instinct of the moment is their only guide (pp. 27–30).

The common European estimate of the negro, according to Olivier, is that

he is brutish, benighted and unprogressive, . . . "half-devil and half-child" ("White Capital and Coloured Labour," London, 1910, p. 2).

My own experience compels me to accept Le Bon's estimate as applicable to our American pure negro in perhaps slightly less extreme form, and with occasional exception; but "devil" is no more applicable to him than to white "brutes." Le Bon's description would seem to describe fairly accurately the racial characteristics of the negroes. The opinion of many men with whom I have discussed this matter confirms me in this judgment. The average of the Caucasian race is by implication characterized by the opposite traits of the typical negro.

The negro differs from the Caucasian in several well-marked anatomical characteristics. Any one who has associated with negroes detects even more striking mental or temperamental differences. These are quite obvious to teachers of mixed schools, fairly common in certain northern states. Where negro, mulatto and white are jointly concerned the teachers are unequivocal in their opinion that mental alertness and the development of the higher psychical activities corresponds in degree quite uniformly with the amount of "white" blood as judged by color of the skin. Le Bon also is quite emphatic on this point:

Each race possesses a mental constitution as unvarying as its anatomical constitution (p. 6).

and

The mental abyss that separates them (negro and white) is evident (p. 28).

This "mental constitution" is the source of a race's "sentiments, thoughts, institutions, beliefs and arts," its "soul."

Where does the mulatto stand with respect to negroes and whites? In general, as a race, approximately midway. But it includes types combining the best as well as the worst of both races. The former almost certainly predominate at the present time.

In Jamaica, according to Governor Olivier,

In practise it is the fact that the pure negro does not show the business capacity and ambition of the man of mixed race, and there are few, if any,

persons of pure African extraction in positions of high consideration, authority or responsibility (p. 34).

Respecting the status and worth of the mulatto in Jamaica, Governor Olivier expresses the opinion that he is

an acquisition to the community, and, under favorable conditions, an advance on the pure-bred African . . . an indispensable part of any West Indian community, and that a colony of black, colored and whites has far more organic efficiency and far more promise in it than a colony of black and white alone. . . . The graded mixed class in Jamaica helps to make an organic whole of the community and save it from the distinct cleavage (p. 38).

The mulatto has appeared through the white man's acts. He will greatly increase in the coming generations, by breeding with both his kind and with pure negroes. A high fertility is increased relative to the negro by a lessening death-rate. It is fortunate that he represents an advance on the negro, and a real national advantage in our efforts to adjust the negro "problem."

Three further questions must be considered before a summary can be given of the mulatto's social and civic value. (1) Are there fairly well-fixed upper limits of mental capacity for negroes and mulattoes? (2) What are the known and established principles of inheritance of racial traits of negroes and whites; in other words, will it be possible by some control of hybrid and inter-racial crosses to produce a colored stock in which a majority may combine the desirable traits of both white and negro? (3) Will it be possible under the constitution and its present amendments to deal with the problem in accordance with the dictates of science and common sense?

With respect to the first point then: We have here only opinion; but it is absolutely unanimous: the negro can not undergo mental development beyond a certain definite maximum.[2] The curious thing

[2] Since this was written I have seen practically the contrary conclusion stated by Professor Herbert Adolphus Miller, of Olivet College, Michigan, in a work which he has kindly permitted me to read in manuscript and from which he allows me to quote. This is a splendid investigation, unique from the standpoint of its materials, and marked especially by originality and caution. In essence it is exactly the sort of research I am pleading for in my paper. "Psychophysical tests" were "given to 2,488 Negroes, 520 Indians and 1,493 Whites, including 596 Mountain Whites in the Tennessee and Kentucky Mountains." Six tests were employed for (1) Memory (*a*) discontinuous; (*b*) logical; (2) Rational Instinct; (3) Imagination; (4) Color Choice; and (5) Reaction Time. He summarizes his conclusions as follows: (1) There is no sharp line of demarcation between the races within the range of the given tests; (2) the differences are of degree, not of kind; (3) this degree is not a race-limitation, for many whites are inferior to many negroes, even in logical memory; (4) from the standpoint of original endowment there is nothing in kind to differentiate the negro from the Caucasian; (5) no faculty is lacking in the negro, and there are some that are especially strong; (6) *limits of capacity do not follow race lines* (italics my own.) The question arises as to how far these

is that no attempt is made to establish this opinion on a scientific basis, and to definitely determine that limit of mental development beyond which the law of diminishing returns dictates cessation of effort; and furthermore, that in flat contradiction to this common opinion education is planned in apparent utter disregard of it.

We are now in possession of a fairly precise and very simple method of determining innate mental capacity in the Binet-Simon series of mental tests. These tests ought at once to be applied to several thousand each of negro and colored school children. The results should yield a fairly accurate idea as to the relative capacity for education and the limits for each. This is of very practical importance. If it can be shown that the negro brain has definite, relatively low limits of flexibility and development, money should not be spent in attempting the impossible. This is the more serious in view of the common inadequacy of educational facilities. The limit of economical educative return being determined, the negro should be given the best possible opportunities for reaching the uppermost range. This would be to the best interest of white and negro alike. If the returns indicated, as is commonly assumed, that mulattoes are endowed with a higher educable limit, national interests again demand that they be given means of attaining the maximum capacity.

The point is that our activities along educational lines, seeing that the financial resources of the states most intimately concerned are relatively meager, should follow clearly indicated paths as determined by scientific facts. Even with our present knowledge it would seem that wisdom and foresight should take more practical heed of Booker Washington's keen suggestion and example, namely, that the education of the negro be for the present chiefly along industrial, and secondly moral lines. The Binet tests would also early detect the feeble-minded and mentally defective, an especially serious menace in an already naturally handicapped race. Very rigid safeguards should be provided against the reproductive liberty of these unfortunates, so that the race suffer no internal contamination. A first step in the scientific approach of this fundamental aspect of the "problem" would certainly seem to be the very extensive study of colored mentality by the Binet measuring scale. We shall work largely in the dark until we have this information.

With respect to the second point: Until recently it was believed that mulattoes generally bred true and became progressively lighter

conclusions follow from neglect, or inability, to differentiate the *mulatto* from the *negro*. Moreover, the Binet tests seem to me superior for the purpose in hand to those employed by Professor Miller, and for this reason, and also because scientific work touching so important and serious a matter needs confirmation and reconfirmation, should be used in further more extensive similar investigations.

with succeeding generations. We now know that skin color in inheritance follows in general Mendelian laws of inheritance, frequently giving rise to white and black "sports" in every large family of mulatto children. In accordance with Mendelian principles, the result of a white-negro cross is always brown-skinned, the dark skin color *dominating*. "White" and "black" skin colors are a pair of *unit characters*. White color means the absence of the *determiner* for deep pigmentation in the germ-plasm; dark skin is due to the presence of such *determiner*. When first generation hybrids intermarry, in an appropriately large family there will appear invariably one or several children lighter than either parent, and one or several darker; that is, the "lighter" and the "darker" have reverted to the grandparental character for skin color. This reveals the fact of a *segregation* of the determiners of skin color in the germ-cells, producing a *purity of gametes*.

We are now in possession of facts, thanks mainly to the labors of Professor Karl Pearson and his collaborators at the Galton Eugenics Laboratory, and to Professor Davenport and his staff of assistants at the Eugenics Record Office, showing that the inheritance of several scores of human physical and mental traits are in close conformity with Mendelian formulæ. There is no countervailing fact, and there is much precise and yet more suggestive data, to the assumption that many of the really desirable negro traits (*e. g.*, physical strength, resistance or relative immunity to certain infections, capacity for routine, cheerful temperament, vivid imagination, rhythmic and melodic endowment, etc.) are of the nature of *unit characters* and as such may be transmitted according to fixed laws by simple control of matings.

If a demi-god could thus experiment with human crosses, as biologists now do with animal breeds, a pure race could undoubtedly be established combining the best elements of the negro and the white. I am well aware that little could probably be actually accomplished under present social conditions, even if it were not morally inimical, to make the experiment by legal control of negro and mulatto crosses. But some little could be accomplished by education and the arousing of the sentiment of colored racial pride. The point seems clear that in the presence of 2,000,000 mulattoes, steadily increasing in number, of relatively superior worth to the pure negro, we have a key to the solution of our problem. The mulatto is the leaven with which to lift the negro race. He serves as our best lever for negro elevation. The mulatto does not feel the instinctive mental nausea to negro mating. He might even be made to feel a sacred mission in this respect. The negro aspires to be mulatto, the mulatto to be white. These aspirations are worthy, and should be encouraged. Possibility of marriage

with mulatto would be a very real incentive to serious efforts for development on the part of the negro. The logical conclusion may follow in the course of the ages. At any rate from present indications our hope lies in the mulatto. A wise statesmanship and rational patriotism will make every effort to conserve him, and imbue him with his mission in the interests of the brotherhood of a better man. The problem seems possible of solution only as the mulatto will undertake it, with the earnest help of the white.

But Le Bon tells us the cross-breed has no "soul." Surely a soulless race would be a world calamity! But these words are poetical, not scientific. A mulatto has no more lost his soul in being hybrid or a descendant thereof than I should if I were to take up my abode in Fiji. This would surely hurt. But I should be no less a man for all my mental pain. The experience might conceivably work to the expansion of my soul. The mulatto is as loyal to his country, his friends and his conscience, according to his lights, as a "white" man. He is just as sensitive. He feels as deeply, experiences the same thrills of happiness as other rational human beings. He has a soul in as true a sense as the word is used by Le Bon as any man. He has more truly a soul in this sense than the "thoroughbred" professor who has lost his childhood's religious faith. Olivier says on this point:

> Whereas the pure race in its prime knows one man only, itself, and one God, its own will, the hybrid is incapable of this exclusive racial pride, and inevitably becomes aware that there is something, the something that we call human, which is greater than the one race or the other, and something in the nature of spiritual power, that is stronger than national God or will. What were, to each separate race, final forms of truth, become, when competing in the focus of our human consciousness, mutually destructive, and each recognizably insufficient. Yet the *hybrid finds himself still very much alive, and not at all extinguished with the collapse of his racial theories* (p. 25, italics my own).

The truth is that the hybrid finds himself *alive* and *human*, with all that this signifies in terms of capacity for soul development. The pure-bred has no better initial equipment. In the matter of human fundamentals they come to differ only as a different nurture plays upon a very similar human nature. There surely are no real data for the support of Le Bon's notion that contrary heredities sap the vitality of hybrids and leave them barren of soul.

The last point is equally difficult, but, like the preceding two, not forbidding. It may be briefly more or less summarily disposed of. The negro can not afford to surrender aught granted him under the constitution. It would be harmful to both colored and whites at this stage of progress to have such alteration achieved as would give the governing powers the free hand exercised by the English in their treatment of the negro of Jamaica. A comparison of conditions as between

the United States and Jamaica with reference to its negro population, however, shows us floundering far in the distance. How can English colonial conditions be paralleled without violence to our constitution? By a simple method, apparent to all, the adoption of which would work incalculable benefit to our nation. The canker of our present political condition as it affects the negro is the moral sore of a stultified conscience. Very naturally when the negro realizes that the constitution makes him politically the equal of any white man, while he knows he is an inferior individual, if indeed only in the sense that a child is inferior to an adult, he detects a first inconsistency. This he accepts; and views equal suffrage as a gift. But when he further realizes that equality of suffrage is a theory, which is disregarded in practise, he sees an inconsistency which he resents, and which moves him to loss of respect. This is the root of distrust and dissimulation and antagonism, which is at the source of the troubles which constitute our "negro problem." Skin color among mulattoes is no scientific index of potential civic worth.

In brief, a state's right of suffrage should be based upon reasonable and uniform qualifications applied actually, as verbally, to all alike of whatever color (and finally sex). No ballot is free from the potentiality of great ill, unless it be cast by an honest, thrifty and intelligent hand. Appropriate educational and property qualifications uniform for all members of a state, and probably as between states, is a reasonable, just and right requirement. This is a first step, for which we already have the light of reason. Further steps must be taken more or less cautiously coincidently with accumulating scientific data. The "problem" is bright with hope; but it must be approached with charity and consistency and with scientific skill and courage.

THE EVIDENCE OF INORGANIC EVOLUTION

BY SIDNEY LIEBOVITZ

WHEN we consider the marked resemblances and striking interrelations of the elements as expressed by the Periodic System, the conviction grows more and more strongly upon us that this system is the external expression of a fundamental process in nature, to which are due the general properties, as well as the individual characteristics, of the elements. On the present occasion I shall endeavor to point out that between the Periodic classification and the ordinary zoological classification, such analogies exist as tend to indicate an identity in fundamental principle. We shall then consider some of the phenomena which are at the foundation of the law of organic evolution, and here, too, we shall find among the elements conditions exactly corresponding.

A Family of the Elements Compared with a Homologous Series

Before proceeding farther, however, it is of interest to note the similarities which exist between a family of the elements and a homologous series of organic compounds. For the purpose of this comparison it is most useful to select the homologous series of fatty acids, $C_nH_{2n+1}COOH$. If we should arrange the normal acids of this series in order of molecular weight, we should find that between such a series and a family of the elements there exist certain close analogies, which are tabulated below in parallel columns.

Fatty Acids ($C_nH_{2n+1}COOH$)	*Family of the Elements*
1. There is a constant difference in molecular weight between consecutive members of 14, due to the constant group difference CH_2.	1. There is a fairly constant difference in atomic weight between consecutive elements of the same family of about 45, except between the first and second (and in some cases between the second and third), where it is about 16.
2. The first member of the series, formic acid, differs somewhat in properties from the other members of this homologous series. Thus, it manifests the characteristics of an aldehyde, reducing ammoniacal solutions of silver nitrate, etc. It has no corresponding chloride or anhydride, is readily decomposed into CO and H_2O, etc.	2. The first member in each family of the elements differs somewhat from the other members. Thus, lithium differs from the other elements of its family in forming an almost insoluble carbonate and phosphate. Oxygen, again, differs from sulphur, selenium and tellurium in that its hydride is a colorless and odorless liquid, while those of the others are gases of disagreeable odor; in that it is seldom, if ever, more than divalent; in being gaseous under ordinary conditions of temperature and pressure, etc.

3. Several compounds of this series, which theoretically may exist, are unknown. Thus, between arachidic and behenic acids there is no acid corresponding to C_{20}. Between behenic and lignoceric there is none corresponding to C_{22}. Similarly, several acids are missing between cerotic and melissic.	3. Many elements which theory predicts should exist are unknown in the Periodic Table. Thus, elements are missing between silver and gold, between cadmium and mercury, etc.
4. The vacant places are all found in the lower part of the series, *i. e.*, among the heaviest molecules.	4. The vacant places all occur in the lower part of the Periodic Table, *i. e.*, among the heaviest atoms. The first four periods are complete (excepting the manganese family). In the last three periods many empty places appear.
5. *Isomeric* forms occur in the series, *e. g.*, butyric and isobutyric, caproic and isobutyl acetic acids.	5. *Allotropic* forms occur in several of the families, *e. g.*, the various forms of phosphorus, of sulphur, of carbon.
6. In a homologous series in general, the melting points, boiling points and specific gravities change uniformly and progressively with increase in molecular weight. In this particular series (considering, as before, only the acids with normal structure) the boiling points and specific gravities show this progressive change, and the melting points do also from caprylic acid on.[1]	6. Generally speaking, the melting points, boiling points and specific gravities change progressively and uniformly in each family of the elements with increase in atomic weight.
7. The acidity decreases with increasing molecular weight.	7. The oxides of the elements become successively less acidic (or more basic) in each family with increasing atomic weight.

The above relations show that *a family of the elements possesses all the characteristics of a homologous series.* There is evidently some identity of principle in the two things compared. We know that in the one case there is in the whole series a common plan of molecular structure, the differences in the structures of the successive normal acids being due to the constant and progressive addition of the same group of atoms, CH_2; and hence it seems reasonable to suppose that there is likewise in each family a common plan of atomic structure,[2] to which are due the properties common to a family.

[1] The physical constants here used (as well as the tabulation of the acids) are those given by Leathes, "The Fats," pp. 10–11. Other authors include several acids (*e. g.*, pelargonic, undecylic) not mentioned by Leathes.

[2] For example, grouping of electrons, according to the well-known theory of J. J. Thomson.

The Arguments from Classification

The fact that the groups of organisms fall naturally into a certain classification is in itself evidence of their origin by evolution.[3] Now, the most salient characteristic of this classification is a division into groups, and a subordination of groups within groups.

> There is a breaking up into groups and sub-groups, and sub-sub-groups, which do not admit of being placed in serial order, but only in divergent and re-divergent order. . . . The Alliances are subdivided into Orders, and these into Genera, and these into Species.[4] . . . The conception finally arrived at, is, that of certain great subkingdoms, very widely divergent, each made up of classes much less widely divergent, severally containing orders still less divergent, and so on with genera and species.[5]

If we examine the characteristics of the Periodic classification, we shall find there the same peculiarities as have been observed in zoological classifications. Thus, there are the nine groups of elements, each quite distinct from the others, and each, as we have shown, very probably having a distinct plan of atomic structure common to all the members of the group. These nine groups correspond to the twelve phyla of organisms. Each group, again, is divided into two families, corresponding to the classes into which organic phyla are divided. That we have no further subdivisions corresponding to those in the organic classification is doubtless due to the circumstance that the number of elements is extremely small as compared with the number of species of animals. When we remember that even with this small number of elements, the Periodic classification presents many irregularities—as forcing into the same family elements with widely different properties (*e. g.*, the copper family); creating a group of "transitional elements" different in the principle of its arrangement from the other groups; the breaking of the periodic sequence by argon, which is greater in atomic weight than potassium, yet precedes it in the series, and by tellurium, which bears a similar relation to iodine; and the irregularities presented by the rare earths—when these facts are considered, it can scarcely be doubted that if the number of the elements were at all comparable to that of organic species, the classification of the elements would necessarily present a subdivision of group within group as extensive, perhaps, as that found among organisms. Moreover, the periodic relation would probably be largely obscured by the great number of its irregularities and contradictions.

Since the classification into which organisms are naturally arranged, of group subordinated to group, is regarded as an indication of evolution, as previously stated; the fact that a similar arrangement is found in the classification of the elements suggests (when we consider also

[3] For a detailed discussion of this point, which can not be given here for lack of space, see Spencer, "Principles of Biology," Vol. I., pp. 356–359.

[4] Spencer, *loc. cit.*, p. 297.

[5] Spencer, *loc. cit.*, p. 358.

the other evidence to be presented) that we may regard the latter system in the same light.

Another peculiarity of organic classification, which, as shown by Spencer, is important because of its indication of evolution, is the variable degree of differentiation between corresponding groups and sub-groups.

> . . . The successively subordinate classes, orders, genera and species, into which zoologists and botanists segregate animals and plants have not, in reality, those definite values conventionally given to them. There are well-marked species, and species so imperfectly defined that certain systematists regard them as varieties. Between genera, strong contrasts exist in many cases; and in other cases, contrasts so much less decided as to leave it doubtful whether they constitute generic distinctions. So, too, it is with orders and classes; in some of which there have been introduced intermediate sub-divisions having no equivalents in others. Even of the sub-kingdoms the same truth holds. The contrast between the Molluscoida and the Mollusca is far less than between the Mollusca and the Annulosa, and there are naturalists who think that the vertebrata are so much more widely separated from the other subkingdoms, than these are from one another, that the Vertebrata should have a classificatory value equal to that of all the other subkingdoms taken together.[6]

Although at first thought this peculiarity may not seem to be of much importance, yet Spencer showed, by comparison with the case of languages, in which exactly analogous characteristics are observable, and in which evolution is known to have taken place, that it is an additional indication of evolution.[7]

> If, then, the classification of organisms results in several orders of assemblages, such that assemblages of the same order are but indefinitely equivalent; and if, where evolution is known to have taken place, there have arisen assemblages between which the equivalence is similarly indefinite; there is additional reason for inferring that organisms are products of evolution.[8]

It will be evident that these observations concerning the organic classification apply with equal force to the Periodic classification. For instance, the elements of the alkaline earth family are not as sharply separated from those of the alkali family as they are from the inert gases or the halogens, and similar remarks apply to the other families. Within each group, too, the extent to which the two families comprising it differ from each other varies in the different cases. Thus, the elements of the chromium family are not as sharply distinguished from those of the oxygen family as the members of the copper family are from the alkalies. In the case of the elements, as in that of the organisms, the various groups and sub-groups differ from each other in the extent to which they are distinct from corresponding groups and sub-groups; and since in the latter instance, as we have seen, this peculiarity affords an additional indication of evolution, we have reason (when we consider

[6] Spencer, *loc. cit.*, p. 361.

[7] For a detailed discussion of this point, see "Principles of Biology," I., 361–362.

[8] Spencer, *loc. cit.*, p. 362.

also the other evidence) for so regarding it in the case of the elements also.

One other analogy demands recognition. Although, as previously stated, the phyla of organisms differ widely from each other, yet animals belonging to different phyla often show marked resemblances to each other in particular features. This phenomenon is a consequence of "the identity of plan, under the most diverse conditions of organization and habits of life (which prevails) not only among animals of the same group, but also between those of different groups."[9] For instance, regarding the affinities of the Rotifera (Phylum Trochelminthes) Parker and Haswell[10] state that

> Their general resemblance to the free-swimming larvæ of Annelids is extremely close. . . . The excretory organs recall those of Platyhelminthes, and also resemble the provisional nephridia or head-kidneys of Annulate larvæ.

Resemblances are also noted between the Class Gephyrea (Phylum Annulata) and Phoronis (Phylum Molluscoida).[11] The Crustacea (Phylum Arthropoda) "belong to the same general type of organization as the articulated worms [Phylum Annulata]."[12] Of the Phylum Mollusca it is stated that

> The Mollusca . . . form an extremely well defined phylum, none of the adult members of which approach the lower groups of animals in any marked degree. There are, however, clear indications of affinity with "worms," especially in the frequent occurrence of a trochosphere stage in development, in the presence of nephridia, and in the occurrence, in *Amphineura* and some of the lower Gastropods, of a ladder-like nervous system resembling that of some Turbellaria and of the most worm-like of Arthropods, *Peripatus*. *Rhodope,* moreover, shows certain affinities with flat worms.[13]

Similarities are also pointed out between the sponges (Phylum Porifera) and the Cœlenterata.[14]

Corresponding to these counter-resemblances in structure among organisms, we have counter-resemblances in properties among the elements. Thus, mercury (Group II.) resembles copper (Group I.) in that both form two series of compounds, monovalent and divalent respectively, both form halides insoluble in water and decomposed by light, etc. Aluminum (Group III.) is similar to chromium (Group VI.) in that the hydroxides on heating give the oxides Cr_2O_3 and Al_2O_3, respectively, in that they form no stable sulphide or carbonate, etc. Thallium (Group III.) resembles, on the one hand, lead (Group IV.) in its metallic properties, in forming a chloride with properties similar to those of lead chloride, while, on the other hand, it resembles the alka-

[9] Claus and Sedgwick, "Zoology," Vol. I., p. 54.

[10] "Zoology," Vol. I., pp. 309–310.

[11] Parker and Haswell, *loc. cit.*, p. 461. The zoological classification followed throughout is that given by these authors.

[12] Parker and Haswell, *loc. cit.*, p. 556.

[13] Parker and Haswell, *loc. cit.*, pp. 750–751.

[14] Parker and Haswell, *loc. cit.*, pp. 215–216.

lies (Group I.) in forming a hydroxide which is soluble in water and strongly alkaline in reaction.

Other examples, concerning which it is unnecessary to enter into detail, are the resemblances between phosphorus and sulphur; between beryllium and aluminum; between manganese and chromium; between boron, carbon and silicon; between gold and the platinum metals. It will be observed from the zoological examples above cited that the members of a phylum, while showing a greater or less similarity to each other, will often markedly resemble members of different phyla. The examples I have given show that a similar phenomenon is often characteristic of the elements of a family—the elements compared are in most cases similar to the other elements of the same family, while having at the same time the points of resemblance with each other described; and since the relationships referred to between distinct groups of organisms are believed to indicate a common origin, we may, perhaps, consider the analogous phenomena among the elements as of the same import.

Did space permit, other analogies might be pointed out between the Periodic and the zoological classifications; but enough has already been indicated to show that the Periodic classification possesses the main characteristic features of the zoological classification.[15] Now, the fact that these characteristics of the latter system are in themselves an indication of organic evolution suggests that the Periodic classification may be regarded in the same light, as I have already indicated. This suggestion is strengthened by the further evidence now to be considered.

The Homologue of the Embryological Evidence; the Phenomena of Radioactivity

The study of comparative embryology has brought to light certain facts which constitute important evidence of organic evolution; for many of the higher animals, in their immature forms, pass through stages in which they resemble more or less the adult forms of other animals, lower in the scale of differentiation. Moreover, animals of distinct but related species, in the progress of their development, often show marked similarities of structure. Von Baer

> found that in its earliest stage, every organism has the greatest number of characters in common with all other organisms in their earliest stages; that at a stage somewhat later, its structure is like the structure displayed at corresponding phases by a less extensive multitude of organisms; that at each subsequent stage, traits are acquired which successively distinguish the developing embryo from groups of embryos that it previously resembled—thus step by step diminishing the class of embryos which it still resembles; and that thus the class of similar forms is finally narrowed to the species of which it is a member.[16]

[15] The periodicity factor in the classification of the elements will be considered later (p. 97).

[16] Von Baer, quoted by Spencer, "Principles of Biology," Vol. I., p. 365.

This statement is now known to be too broad, but is true in general principle.[17] Again,

The embryos of the most distinct species belonging to the same class are closely similar, but become, when fully developed, widely dissimilar.[18]

To cite a few examples: The human embryo, at one stage of its development, possesses the rudiments of gill arches and gill clefts. The larvæ of most insects, no matter how diverse, pass through a worm-like stage.

The larvæ of most crustaceans, at corresponding stages of development, closely resemble each other, however different the adults may become, and so it is with very many other animals.[19]

It is with the latter of the two embryological peculiarities mentioned above, viz., the resemblances between the embryos of different related species, that we are at present concernd.

In the radioactive transformations, we have not the advantage of witnessing a building up of elements from simple to complex forms, as in the process of embryology we observe the formation of complicated organisms from the egg. But, what is almost as good, we observe a *devolution* of elements, from complex forms to simpler. In the course of their disintegration, the three distinct elements, radium, thorium and actinium give rise to products (*i. e.*, elements) which have very similar properties.

The substances thorium, radium and actinium exhibit many interesting points of similarity in the course of their transformation. Each gives rise to an emanation whose life is short compared with that of the primary element itself. Such experiments as have yet been made, indicate that these emanations have no definite combining properties, but belong apparently to the helium-argon group of inert gases. In each case, the emanation gives rise to a non-volatile substance which is deposited on the surface of bodies and is concentrated on the negative electrode in an electric field. The changes in these active deposits are also very similar, for each gives rise to a rayless product, followed by a product which emits all three types of rays. In each case, also, the rayless product has a longer period, or, in other words, is a more stable substance than the ray product which results from its transformation.

The disintegration of the corresponding products, thorium *B*, actinium *B* and radium *C* is of a more violent character than is observed in the other products, for not only is an α particle expelled at a greater speed, but a β particle is also thrown off at great velocity. After this violent explosion within the atom, the resulting atomic system sinks into a more permanent state of equilibrium, for the succeeding products thorium *C* and actinium *C* have not so far been detected by radioactive methods, while radium *D* is transformed at a very slow rate.

This similarity in the properties of the various families of products is too marked to be considered a mere coincidence, and indicates that there is some underlying law which governs the successive stages of the disintegration of all the radioelements.[20]

[17] Cf. Spencer, *loc. cit.*

[18] "Origin of Species," Vol. II., Ch. XIV.

[19] *Loc. cit.*

[20] Rutherford, "Radioactive Transformations," pp. 169–170.

Starting out, therefore, with three distinct elements, we find them going through a process of change, in the course of which all three evolve products of very similar properties. If we regard this process of disintegration as in the main a reversal of a process of evolution which once took place, *i. e.*, as a process of *devolution*, we may say, taking, for instance, Ra*G*, Th*D*, and Act *C* as the starting points, that these elements commenced a career of spontaneous change, in the course of which transition products were produced which were quite similar to each other; but ultimately three distinct elements were generated. In the case of the elements, therefore, as in that of organisms, forms which were ultimately to be more or less dissimilar, passed, in the course of their development, through stages in which they closely resembled each other.

It is still more instructive if we consider the stages in the ontogeny of various animals in *reverse order*. We should then find, taking the crustacea, for instance, as examples, that starting out with even the most diverse forms of these animals, and imagining them to go through the stages of their development in reverse order,[21] they would grow more and more similar as they approached the larval stage, and when they reached that condition, would be very much alike at corresponding stages of development; just as radium, thorium and actinium are much alike at corresponding stages in their degeneration.

Now, the significance of the embryological phenomena referred to is that these resemblances between animals of quite distinct groups are believed to indicate an ultimate common ancestry for the organisms so related; and since we have observed a condition which we may consider comparable to this among the elements, it seems probable that those radioactive elements which exhibit such close similarities as we have described as their disintegration progresses, originated by evolution from a primary simpler substance; it seems probable, that is, when taken together with the other evidences of evolution herein adduced.

Even if we disregard analogies, the fact that three distinct elements consistently show marked similarity in properties in the course of their disintegration would lead to the presumption that, if we could follow them back far enough, they might prove to be identical. This presumption is strengthened by the analogy we have considered.

It may be remarked that the changes occurring during radioactive disintegration are further similar to those which take place in ontogeny, in that in the former, as in the latter, the various stages are not permanent, but change continuously into other stages; and these changes are in both cases spontaneous, taking place without the aid of any external agency.

[21] Such a process need not be wholly imaginary, however; phenomena comparable to this are found in the instances of so-called retrograde development.

The Homologue of the Geological Record; Spectroscopic Evidence

Another source of evidence for the evolution of organisms is that derived from the study of paleontology; for the successive geological strata constitute a record of the organic forms which have successively inhabited the earth; a record which shows that in all the forms of life there is a considerable degree of continuity, and a (more or less) gradual transition from one form to another.

The homologue of this geological record in inorganic evolution is to be found in the series of stars arranged in order of decreasing temperature; for what the unknown cause of organic evolution has done for organisms, leaving the record in the geological formations, temperature (and perhaps other agencies) have done for the elements, leaving the record in stars of different heat intensities.

Lockyer has shown that the spectroscopic study of the stars, as carried on by himself and others, has revealed evidence of a very important kind for inorganic evolution. Here the results can only be briefly indicated.

As pointed out by Sir Norman Lockyer, the simplest elements appear first.

> . . . In the hottest stars we are brought in the presence of a very small number of chemical elements. As we come down from the hottest stars to the cooler ones the number of spectral lines increases, and with the number of lines the number of chemical elements. . . . In the hottest stars of all we deal with a form of hydrogen which we do not know anything about here (but which we suppose to be due to the presence of a very high temperature) hydrogen as we know it, the cleveite gases, and magnesium and calcium in forms which are difficult to get here. . . . In the stars of the next lower temperature we find the existence of these substances continued in addition to the introduction of oxygen, nitrogen and carbon. In the next cooler stars we find silicium added; in the next we note the forms of iron, titanium, copper and manganese, which we can produce at the very highest temperature available in our laboratories; and it is only when we come to stars much cooler that we find the ordinary indications of iron, calcium and manganese and other metals. All these, therefore, seem to be forms produced by the running down of temperature. As certain new forms are introduced at each stage, so certain old forms disappear.[22]

The stellar evidence, like the geological record, is incomplete, because, as stated by Lockyer, of the very small range of the photographs of stellar spectra, and also because

> It does not at all follow that the crucial lines of the various chemical substances will reveal themselves in that particular part of the spectrum which we can photograph.[23]

But whatever has been gleaned from the stellar evidence, though incomplete, is, like the information contained in the geological record, very significant in its indications of evolution.

[22] Lockyer, "Inorganic Evolution as Studied by Spectrum Analysis," p. 159.
[23] Lockyer, *loc. cit.*, p. 161.

The close analogies which we have shown to exist between the periodic and the zoological classifications would seem to point toward a fundamental identity of principle in these two systems. I have endeavored to show that there are in the inorganic world the exact homologues of some of the most important facts upon which the law of organic evolution rests, *i. e.*, the evidence of the geological record and of the embryological resemblances; to emphasize the importance of the spectroscopic evidence; and to show that the Periodic classification is in its main aspects identical in its nature with the zoological classification. These facts tend to indicate that the groups of the elements correspond to the phyla of the organisms, in being the outward expression of a process of evolution. The periodicity in the arrangement of the elements is expressive of the fact that in each family there is the same plan of atomic structure, and a gradual and progressive change in this structure as we traverse the groups from the inert gases to the halogens. That it is an imperfect relationship is shown by its numerous contradictions, already mentioned. These facts, however, harmonize entirely with the evolutionary view, for zoological classifications show just such irregularities. Moreover, according to the evolutionary view, an element need not necessarily be smaller in atomic weight than the next in the same series. The evolutionary view is entirely compatible with those phenomena, which seem to be out of harmony with the Periodic classification.

If the species of organisms were few enough and their structure simple enough, it seems likely that it would be possible to select some common characteristic which would serve as a basis of periodicity corresponding to that in the elements. Conversely, as has already been indicated, if the number of the elements were at all comparable to that of organic species, it is probable that the Periodic relation would be largely obscured by the great number of its exceptions.

Without the knowledge of the fact of organic evolution, the arrangement of animals and plants into classes, with their numerous group resemblances and counter resemblances, must have seemed a purely arbitrary one, having no basis in nature.[24] Similarly, when we consider the characters of the elements of the same families, their close resemblances to each other, and their minor resemblances to members of other families, the irregularities of the Periodic classification, etc., it is evident that we can coordinate these seemingly contradictory phenomena into a coherent whole on the basis of the evolution of the elements. The extraordinary relations disclosed by the Periodic classification are the outward and manifest signs of the process to which atoms, like organisms, owe their individual natures. The process begun in the one (the atom) continues in the other (the organism).

[24] "The propinquity of descent—the only known cause of the similarity of organic beings—is the bond, hidden as it is by various degrees of modification, which is partly revealed to us by our classification." Darwin, quoted by Spencer, "Principles of Biology," Vol. I., p. 364.

A STATISTICAL STUDY OF EMINENT WOMEN

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THE word eminent as used in this study covers the range of meaning designated by the Century Dictionary which defines the term as "high in rank, office, worth or public estimation; conspicuous, highly distinguished." According to the same authority, the word is rarely used in a bad sense. Dr. Francis Galton,[1] who made the first statistical study of distinguished men, defined his use of eminent thus:

> When I speak of an eminent man, I mean one who has achieved a position that is attained by only 250 persons in each million of men, or by one person in each 4,000.

While my selection is closer, mathematically, than Galton's, among the 868 women whom I have designated as eminent, some are included because of circumstances over which they had no control, such as great beauty, or congenital misfortune. Many were born to their positions; to others is due but little credit for the fact that they married men sufficiently eminent to accord them a place in history. Some led spectacular lives and were notorious rather than meritorious. Many of them were women of unusual intellectual ability and were eminent in the ordinary connotation of the term. More or less biographical data are at command concerning these 868 women, and to the extent that reputation may be considered a just index of ability, they are entitled to a place in a catalogue of the distinguished of earth.

In selecting the group I have followed precisely the objective method devised by Professor J. McKeen Cattell[2] in his "Statistical Study of Eminent Men." My method, in detail, was as follows: I went through the Lippincott Biographical Dictionary, the Americana, Nouveau La Rousse, Brockhaus's Konversations-Lexikon, Meyer's Konversations-Lexikon and the Encyclopædia Britannica and noted the name of every woman mentioned in each. I retained for my list the name of every woman noted in any three out of the six encyclopedias or dictionaries. My original intention was to eliminate from the lower end of the group until I had 1,000, a convenient and sufficiently large number with which to work. But when the twenty-three Biblical characters were excluded, the entire number was only 868. It is a sad commentary on the sex that from the dawn of history to the present day less than one thousand women have accomplished anything that

[1] "Hereditary Genius," p. 10, 1869.

[2] "A Statistical Study of Eminent Men," Pop. Sci. Mo., Vol. 62, p. 359, 1903.

history has recorded as worth while. One can not evade the question, is woman innately so inferior to man, or has the attitude of civilization been to close the avenues of eminence against her?

When the list of names was completed, the amount of space accorded the women by the different encyclopedias was reduced to a common standard, and the names arranged in order of merit.

According to our standard of measurement Mary Stuart is the most eminent woman of history. She has no close competitor. Queen Victoria is the most recent of the preeminently gifted women, and therefore has a large probable error of position. George Sand is the most distinguished literary woman, and we may say that the chances are even that her position as fifth in the order of merit is correctly determined. The most eminent woman of American birth is Mrs. Stowe, who ranks twentieth. Had additional or different encyclopedias been used in compiling the list, the chances are one to one that her position would be between 17 and 21.

It must be borne in mind that had other sources been used in selecting the eminent women, the position of certain ones might have shifted more or less. However, we must concede that the women who are ranked in this list as the most eminent are the ones most familiar to us in literature and history, and they unquestionably deserve their position. The twenty preeminently gifted women of history are Mary Stuart, Jeanne d'Arc, Victoria of England, Elizabeth of England, George Sand, Madame de Staël, Catherine II. of Russia, Maria Theresa, Marie Antoinette, Anne of England, Madame de Sévigné, Mary I. of England, George Eliot, Christina of Sweden, Elizabeth Barrett Browning, Madame de Maintenon, Josephine of France, Catherine de Medici, Cleopatra and Harriet Beecher Stowe.[3]

A list of this sort makes possible comparisons which are not ordinarily evident and could not otherwise be made, and the known probable error makes it possible to determine within what limits the comparisons are true. Charlotte Brontë and Charlotte Corday seemingly have nothing in common, yet their respective numbers in order of merit are 21 and 22. Marie Brinvilliers, whose mania for poisoning makes it impossible to classify her as anything but a criminal, just precedes Geneviève, the patron saint of Paris. Joanna Baillie, the poet; Mrs. Siddons, the actress, and Beatrice Cenci, whose beauty and tragic fate have been preserved for us in the colors of Guido Reni and in the lines of Shelley, are numbered 89, 90 and 91, respectively.

The range of eminence covered by these 868 women is wide. Mary Stuart, with 607.67 lines, is more than one hundred and eighty-eight

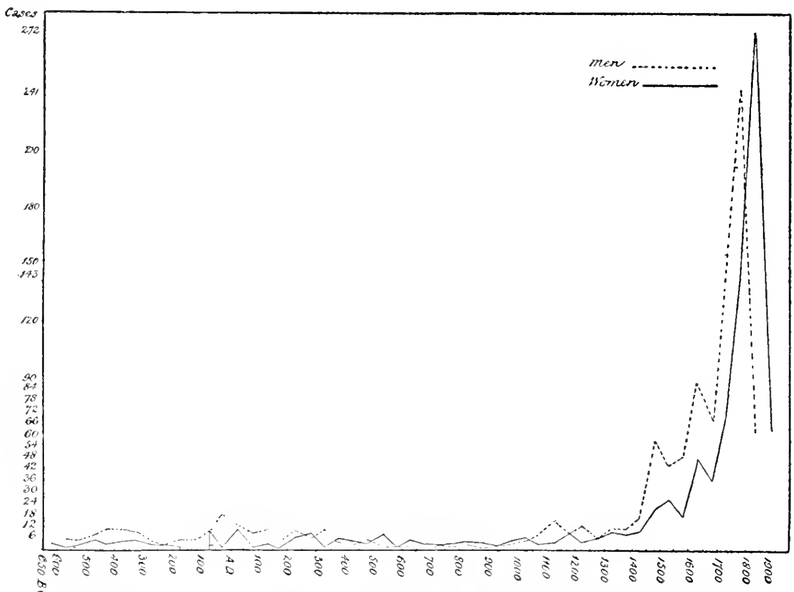
[3] The complete list of the 868 eminent women together with detailed and technical discussion of the data will be found in a thesis accepted for the degree of doctor of philosophy by the department of psychology, Columbia University, to be published in *Archives of Psychology* (The Science Press, New York).

times as eminent as Constance Bonaparte with 3.23 lines. There are forty-nine women who are given one hundred or more lines in the encyclopedias, and there are twenty-seven that are given less than ten lines. The average amount of space accorded is 43.2 lines.

This group of eminent women is spread over a long period of time. From the seventh century before Christ to the nineteenth century after Christ, inclusive, the light of feminine genius has never been extinguished, though sometimes it has burned but dimly. Beginning with three cases in the seventh century before Christ, we observe that the Golden Age of Greece records a rise in the curve. Who knows but that her women were potentially as great as her men, and if Plato's theory regarding the education of women had been universally applied, the curve might not have risen higher? In the second century before Christ, Cornelia, the mother of the Gracchi, is the sole representative. The period of Roman supremacy is clearly depicted, as is also that of the religious persecutions in the third century, eleven of the fourteen representatives of that century being martyrs. Through the Dark Ages, the level of the curve remains almost stationary. There is a little rise in the twelfth century, but a subsequent fall in the thirteenth. This, however, is insignificant because of the few cases. The curve rises considerably in the fourteenth century, almost doubles its height in the fifteenth, and does not drop again. The eighteenth century produces 213 cases, or 24.5 per cent., of the eminent women of history. We must bear in mind the fact that the records for the nineteenth century are neither complete nor accurate. The youngest woman on my list was born in 1880, therefore one fifth of the century is not represented, and one half of it but partially. Ability in woman is more readily and willingly recognized at the present time than formerly, so names of women whose reputation for eminence may not prove enduring may be included in the nineteenth-century group. On the other hand, the eminence of a large group of women is now in the process of making, and subsequent biographers may accord them a more important place than their contemporaries. While the figures for this last century are in no respect accurate, they are in many respects interesting. The century furnished 335 cases, or 38.5 per cent., of the total number of eminent women. Sixty-three per cent. of the eminent women of history were born in the last two centuries. If we were able to compare the number of cases in each century with the population of that period, as Professor Cattell pointed out in his study, the curve would, in some respects, be different from this one. For a partial comparison we have used a modified form of the table of growth of population given by Mulhall[4] and have found that while the number of eminent women produced by England, France, Russia, Austria, Italy, Spain, Germany

[4] "Dictionary of Statistics," 4th edition, 1898, p. 441.

and the United States increased from 28 in the fifteenth century to 187 in the eighteenth century, the ratio of eminent women per ten million of population also increased from 6.1 to 15.3 in the same period. Those who refuse to lose faith in woman's ability may find encouragement in the fact that the gain of the rate per ten million of population of the sixteenth century over the fifteenth was 19.6 per cent.; of the seventeenth over the sixteenth, 27.3 per cent.; of the eighteenth over the seventeenth, 64.5. An interesting conjecture is whether the complete record for the nineteenth century will give a gain per cent. over that of the eighteenth correlative with the increased social and educational advantages which women have attained.



CURVE I. DISTRIBUTION OF EMINENT MEN AND EMINENT WOMEN IN PERIODS OF HALF CENTURIES.

Curve I. shows the distribution of distinguished women and distinguished men in periods of half centuries, the figures for the men being taken from the previously quoted article by Professor Cattell. In comparing the distribution of eminent men and eminent women through the centuries, three facts must be borne in mind. (1) One thousand eminent men were studied, and only eight hundred and sixty-eight women, so the male curve might be expected at all points to rise higher than the female. (2) The eminent men represent a much higher degree of selection than the women. (3) The study of eminent men was made in 1903 and no living persons were included. These facts do not, however, make it impossible for us to note certain similarities and dissimilarities.

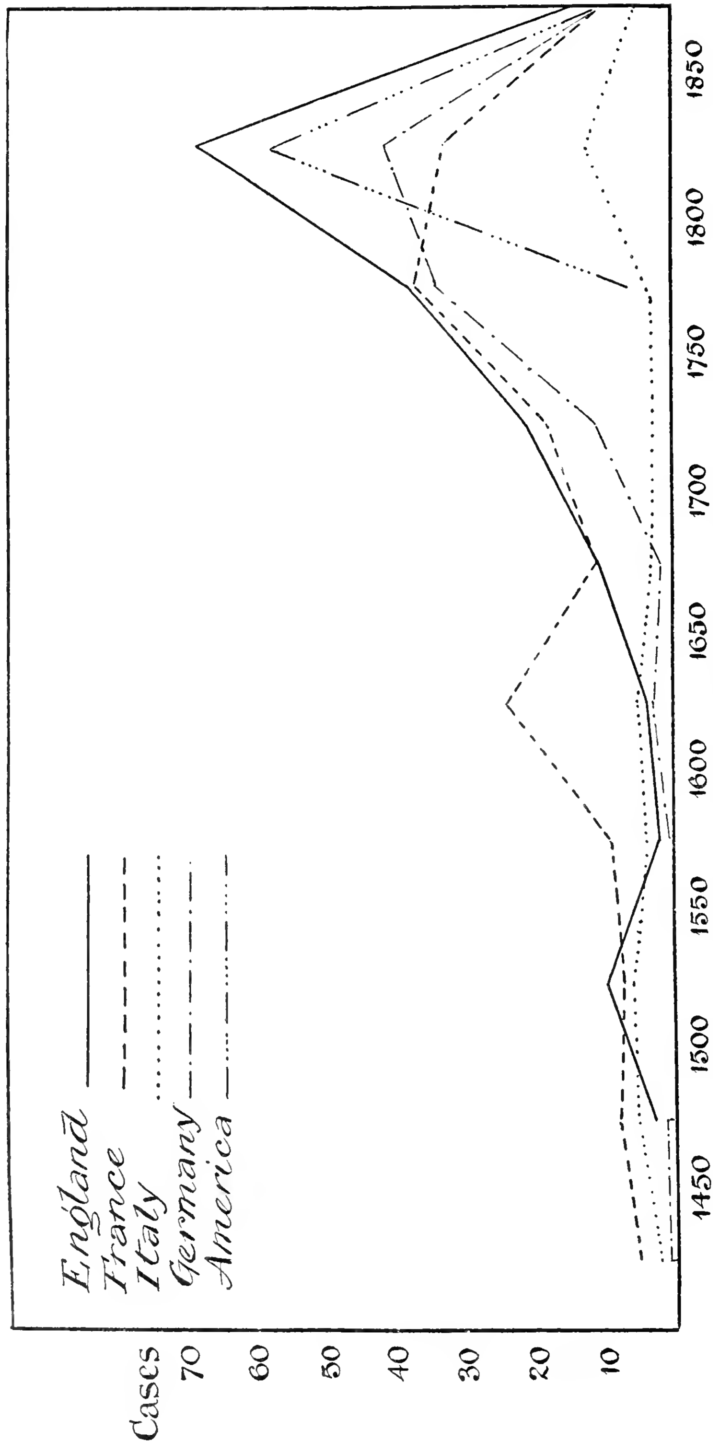
The curves are similar during the period of Greek supremacy. The male curve for the Roman period is much more regular than the female. The last half century of the pre-Christian era which produced more eminent Roman men than any other, produced but one eminent Roman woman. The lines cross for the first time in the second half of the third century after Christ. From the sixth to the eleventh century the number of women equals or exceeds the number of men. With few exceptions, the eminent women of these centuries are sovereigns, abbesses and saints, or belong to the groups "Marriage" and "Birth." If the eminent women were selected as rigidly as the eminent men, the position of the curves through these centuries would undoubtedly be reversed. Of the later period, Professor Cattell writes,

> In our curve there are three noticeable breaks. . . . Thus, in the fourteenth century there was a pause followed by a gradual improvement and an extraordinary fruition at the end of the fifteenth century. . . . There was then a pause in progress until a century later England and France took the lead. . . . The latter part of the seventeenth century was a sterile period, followed by a revival culminating in the French Revolution.

If we except the first half of the sixteenth century, when the male curve fell and the female rose, the identical words might have been written of the eminent women. Whatever the factors in these centuries that cooperated to produce genius, they were effective in both sexes, though to a lesser degree in the one than in the other.

The 868 eminent women are natives of forty-two different nations. England has furnished eight more distinguished women than France. Germany ranks third with 114; America, only two centuries old, is fourth. Italy produced 60, Rome 41, Austria 24, and Spain 23, eminent women. Russia claims 20, Sweden 16, Greece 15 and Scotland 14. Twelve of the eminent women belong to the Byzantine Empire, 11 to Holland, and 9 to Ireland. Twenty-seven nations each produced fewer than ten eminent women.

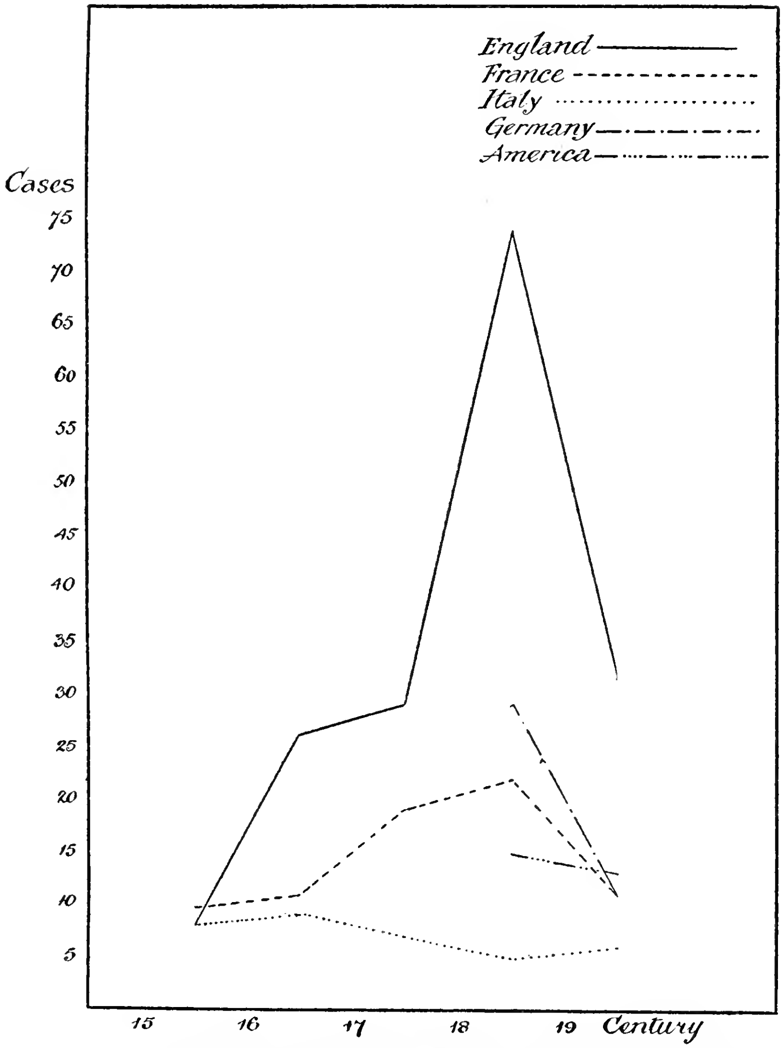
The relative number of women of ability produced by England, France, Germany, America and Italy, at different periods, is shown in Curve II. In the fifteenth century, France and Italy were leading in the number of eminent women. By the beginning of the sixteenth century France was declining and England had surpassed them both. But England had a subsequent fall, and France a rapid rise, at the beginning of the seventeenth century. Later in the century, France declined again; England gained; the German curve rose rapidly; and the Italian remained very low. Of the five modern nations which have contributed the largest number of eminent women, France is the only one for whom the incomplete records of the nineteenth century show a decline in the number of eminent women over the eighteenth century. We quote as peculiarly applicable what Professor Cattell said regarding the eminent men:



CURVE II. THE NUMBERS OF EMINENT WOMEN OF DIFFERENT NATIONALITIES.

The French Revolution brought into prominence many men not truly great, and the position then attained by France is not held in the nineteenth century.

The figures for the last century reveal a third period of Italian activity, chiefly in music and literature. In so far as the data for the nineteenth century are reliable, America gives greater promise for the immediate future than any other nation.



..CURVE III. THE NUMBER OF EMINENT WOMEN OF DIFFERENT NATIONALITIES ON THE BASIS OF POPULATION.

Curve III., which shows the record of these same five nations through the same centuries on the basis of population, is, in one sense, more significant. From the point of view of the number of eminent

women per ten million of population, France is not the only nation whose nineteenth century ratio fails to equal that of the eighteenth. Germany, and especially England, have failed signally in this respect. Italy is the only one of the five modern nations which at present shows a gain in ratio of eminent women according to population, in the last century over the previous one. She seems to be rising out of the trough of a curve, the crest of which was reached in her sixteenth century Renaissance. These figures emphasize the promising situation in America. In another half century, it will undoubtedly be seen that while our population increased from 3,930,000 in 1790 to 50,155,783 in 1880, there was a corresponding increase in the number of American women of ability per ten million of population. No more vital problem in connection with the social and educational life of woman could be propounded than the one revealed by these curves. Is the racial difference an important factor, or must one look to the social conditions and educational opportunities of the time for an explanation? Why is it that England, starting in the fifteenth century with the same ratio as Italy (8 eminent women per ten million of population) should rise in the eighteenth century to 73, while Italy fell to 5? Or, why has the English curve, which started lower than the French, and equal with the Italian, towered, since the sixteenth century, so far above the remaining four? How explain the fact that while France was so prominent in the eyes of the world in the eighteenth century, and her women had unusual opportunity to come into public notice, the number of eminent women on the basis of population being produced by Germany, and especially by England, was far in advance of the number being produced by France? In America, the youngest of the five nations, what is there to explain our present position above Italy, Germany and France, and second only to England? Or, to be more insistent, what would a comparison of modern English and American conditions reveal that would determine that the latter should be second, instead of first, in the ratio of eminent women per ten million of population?

Accustomed as we are to thinking of the sphere of woman as a limited one, it is interesting to note that the 868 women became eminent in twenty-nine lines of activity, if some of the following classifications can be so designated. The distribution is as follows: Literature 337; Marriage 87; Religion 64; Sovereign 59; Actress 56; Music 49; Birth 39; Mistress 29; Scholar 20; Political Influence or Ability 19; Artist 17; Philanthropy 12; Tragic Fate 11; Heroine 10; Motherhood 10; Reformer 9; Dancer 6; Immortalized in Literature 6; Patron of Learning 6; Beauty 6; Educator 3; Revolutionist 2; Misfortune 2; Traveler 2; Adventuress 2; Physician 2; Fortune Teller 1; Conjugal Devotion 1; Criminal 1.

Of the entire group of women 38.8 per cent. won their eminence by

the use of the pen. It is probable that woman has had more opportunity in literature than in any other line of work. Her actions have been restricted in various degrees at different times, and in different localities, and, to a certain extent, her thought has been regulated. It is, undoubtedly, her innate right to reign supreme over her feelings. An analysis of the group of 337 writers shows a large per cent. of feminine literature to be of an emotional or imaginative nature. If, to the group of writers we add the women classed under "Religion," the actresses and the musicians, we note that we have 506, or 58.2 per cent., of the entire group of eminent women before we reach the small group of scholars who have exercised the power of reason. Add to this the artists and dancers as further illustrations of emotional activity, and we still see that the common concept of a woman as a creature of feeling rather than a creature of reason may not be without foundation. If this conception is just, our classification tends to show that when woman has attained eminence, it has not been in spite of her femininity, but rather because of it.

As remote as the seventh century before Christ women became eminent in literature. This early work is poetry and undoubtedly represents the outburst of genius rather than the result of training. In the early centuries, a woman might be born to eminence, and in a few instances she was allowed to govern, but a large percentage of the names that have come down to us as late as the sixteenth century are those of women who were wives of men more distinguished than themselves. The Christian religion made a strong appeal to womanhood, and no century has been without its representative in this field. In the group of 64 eminent women classed under "Religion" in our study, five were founders of sects known respectively as Christian Science, the Buchanites, the Southcottians, the Countess of Huntingdon's Connection, and the Shakers. In addition, Saint Clara founded the Franciscan Order of Nuns; Saint Theresa, the Barefooted Carmelites; Angela Merici, the Ursuline Order; and Jeanne Chantal, the Order of Visitation. Sixteen, or one fourth of the group, suffered martyrdom. Motherhood, heroism and beauty occur occasionally without reference to time or nationality. Actresses date only from the seventeenth century, and musicians from the eighteenth. The reformers, dancers, educators, revolutionists, travelers and physicians are products of the last two centuries. For those who are interested in the problem of the modern woman the record for the nineteenth century ought to be of interest. Of the 335 women of the century, 184 are writers. The stage has been the stepping stone to eminence for more than eight times as many women as became noted because of their religion. If, however, we allow a broad interpretation of religion to include social service, and thus combine the groups "Reformers" and "Philanthro-

pists" with the group "Religion," the ratio is 33 to 19. Forty-three of the eminent women of the century are musicians; eight are artists. There are five scholars. Of the seven women born to eminence in the last century, five are near relatives of Napoleon I., the most eminent man of history.

Of the 337 writers, 108 were English, 58 German, 56 French and 41 American. Rome furnished 10 of the Christian martyrs. Aside from Rome, England, France and Italy have produced most of the saints of history. Seven of the great queens were Spanish, and 7 Russian. Twenty-one of the 56 actresses were French, and 13 English. It has been in France more than in any other country that women have been born to greatness. Only seven nations are represented in the group "Mistresses," France producing 16 of the 29. England, Germany and Italy each claim 3 scholars; America has one, the astronomer, Maria Mitchell. French women have become eminent through politics more than the women of any other nation. The artists are scattered, France and Italy leading with 3 each. Germany and Italy have led in musicians with 9 each. England has led in philanthropy as the work of woman. The social reformers comprise the largest group, which belongs entirely to one nation. These 9 women were Americans.

Although 38.8 per cent. of the entire group of women became eminent in literature, it does not follow that in this line of work they attained the highest degree of eminence. The following table shows the average number of lives given to the different groups. The averages may be considered as indices of merit for the various occupations. The number of cases on which the average is based is indicated in each instance. The results show very clearly that it has been as sovereigns that women have become the most eminent. Second in rank, but reduced to almost one half the degree of distinction attained by the sovereigns is the group of politicians. Motherhood, based on fewer cases than either of the two previous groups, ranks third. This group of mothers does not include women, who, besides having eminent sons or daughters, were themselves distinguished in some line of activity. Such women fall in the several groups in which they achieved fame. This group is comprised of those women whose only claim to eminence is their motherhood. Undoubtedly, they were very capable women. Typical illustrations are Saint Monica, the mother of Saint Augustine, and Lætitia Bonaparte, the mother of the first emperor. The mistresses—which group includes the early Greek courtesans—rank high, and justly so. Our standards have changed, and while our moral sense may be offended at seeing twenty-nine women so classified, we are led to believe that, in many instances, these women, whatever their morals, were intellectually among the most capable of their sex. Restricted by

the social customs of their times, they found in this relation an opportunity to meet and associate with men of their own intellectual power. Were it not so, it scarcely seems probable that mere beauty or pleasing personality which fascinated some weak-minded king could have been sufficient reason for the high degree of merit which history has accorded them.

The artists rank comparatively low in merit. However, if we consider the groups of activity in which women have actually done things—attained their eminence by genuine labor—of the groups sufficiently large in size to expect accuracy in results, we note that the artists rank higher than the actresses, writers or musicians. A possible explanation of the very low degree of merit accorded the musicians is the fact that 43 of the 49 belong to the nineteenth century, and of these 43, 20 are living at the present time, so their merit is not yet accurately determined.

The merit of George Sand, Madame de Staël, Madame de Sévigné, George Eliot, Mrs. Browning, Mrs. Stowe and Charlotte Brontë is not sufficient, when grouped with so many writers of less ability, to bring the average for the group "Literature" to more than 29.74.

INDEX OF MERIT FOR OCCUPATIONS

	Average No. of Lines	No. Cases on which Average is Based
Sovereign	112.10	59
Political influence	62.13	19
Motherhood	46.14	10
Mistress	46.09	29
Beauty	44.62	6
Religion	43.58	64
Tragic fate	42.83	11
Marriage	38.09	87
Patron of learning	37.60	6
Heroine	35.46	10
Scholar	35.35	20
Artist	34.54	17
Reformer	32.29	9
Actress	32.02	56
Literature	29.74	337
Immortalized in literature	29.30	6
Music	27.46	49
Birth	27.45	39

Considerable interest always attaches to the wives of eminent men, and to the husbands of eminent women. Personally, we do not believe that, with rational people, love is blind, hence it seems that a study of the marriage relations of this group of eminent women ought to reveal information, not only interesting, but valuable in throwing light on certain social and psychological problems. We must remember

in this connection, however, that one current definition of genius does not always grant the rationality of the individual. Only lawful marriages are considered in this study; *liaisons* are not recognized. Four morganatic unions are included. Owing to lack of information, ninety-three eminent women are unclassified as either married or unmarried.

One hundred and forty-two, or 16.3 per cent., of the entire number of women of ability, have not married. Of this group, 72.5 per cent. were born in the last two centuries, and 49.2 per cent. of the unmarried eminent women of history belong to the nineteenth century. There is, of course, the possibility that some of our contemporary women of distinction may yet marry, and thus reduce this ratio. England and America have produced 59.8 per cent. of the unmarried women of ability. The former country has twenty-one more unmarried eminent women than the latter, but the figures for America are the more significant, since in terms of per cent. they mean, that of the total number of distinguished women produced by England, 29.7 per cent. of them have not married; whereas, in America, the ratio is 42.6 per cent. It is a pertinent question whether our women realize that in attaining eminence nearly one half the number sacrifice their own homes and families. Our figures do not show that any one line of activity has appealed particularly to the unmarried group. Neither were they, in their freedom from the duties and responsibilities of wifehood and motherhood, able to attain a higher degree of eminence than the married women; nor was their average length of life found to be longer.

Two hundred and fifty-nine of the distinguished women married men sufficiently eminent to be recorded in three or more of the six encyclopedias used in collecting the list of women. The number of lines accorded these husbands was counted and submitted to the same system of standardization as that used for the women. Napoleon I., Peter the Great, Henry IV. of France, Philip II. of Spain, Mark Antony, Nero, Philip II. of France, Claudius, Louis XII. of France, Ptolemy I. and Chilperic I. were each married to two of the eminent women. Five of the wives of Henry VIII. of England are included in our list of distinguished women. On the other hand, twenty-two of the women married more than one husband sufficiently eminent to fall within our classification.

Our knowledge of the relative eminence of the husbands and wives makes possible some interesting comparisons. Eight of the husbands, namely, Napoleon I., Mohammed, Julius Cæsar, Martin Luther, Alexander the Great, Frederick the Great, Socrates and Napoleon III. are more eminent than Mary Stuart, the most eminent woman of history. Jeanne d'Arc and Queen Victoria are less eminent than the poet Shelley, but more eminent than the first Roman emperor, Augustus Cæsar. Mary I. of England is of equal eminence with Philip IV. of France.

Rosa Bonheur and Antoninus Pius are accorded the same number of lines. Thirteen eminent women are less distinguished than King Hakon of Norway, the least eminent of the husbands. We have here an exact means for telling whether Robert Browning is more or less eminent than his gifted wife, and how much; whether the joint sovereigns of England, William and Mary, are equally distinguished; whether Cornelia, the mother, and Tiberius Sempronius, the father, of the Gracchi are equally famous; and whether Otto Goldschmidt is more or less distinguished than Jenny Lind.

The two hundred and fifty-nine eminent women who married men of sufficient distinction to come within our criterion of eminence were natives of thirty-one different nations, but France, England, Germany and Rome produced the larger number of them. Julia Ward Howe, Julia Marlowe and Elizabeth Drew Stoddard are the only noteworthy American women who married husbands sufficiently eminent to be included in our list.

The average age at which eminent women have married (based on 459 cases) is 23.4 years. This means, in each instance, the age when married for the first time. Three of the women were married under ten years; thirty were married before they were fifteen; five married later than fifty. The youngest bride was Joan of Naples, who at the age of six was married to Andrew, Prince of Hungary. The oldest bride was Angela Burdette-Coutts, who at sixty-seven married Mr. Ashmead-Bartlett.

The following table shows a fairly regular tendency through the centuries to postpone marriage from 16.2 years in the twelfth century to 26.2 years in the nineteenth. The range of age of brides has also varied, particularly in the maximum limit. Through the twelfth, thirteenth, fourteenth and fifteenth centuries no eminent woman was married later than thirty. In the last four centuries the maximum limit has varied from forty-three to sixty-seven. In other words, we may say that the maximum age of marriage during the last four centuries (nineteenth, eighteenth, seventeenth, sixteenth) averaged 53.3 years; for the preceding four centuries (fifteenth, fourteenth, thirteenth, twelfth) it averaged 25.8 years.

Age at Marriage in Different Centuries

Century	Average Age at Marriage	No. of Cases on which Average is Based	Range of Age of Brides, Years
19	26.2	189	15–67
18	23.1	127	13–53
17	20.0	50	13–43
16	21.7	28	12–50
15	17.6	20	13–26
14	13.8	11	6–18
13	16.6	5	12–29
12	16.2	5	8–30

There is considerable variation in the average age at which women of ability have married in different nations. Considering only those countries for which we have record of nine or more cases, it has been found that the average age at which American women of ability marry is 27.7 years, which is 9.3 years later than the average age at which Russian women of eminence marry. Distinguished women of English birth marry three years younger than American women, but 1.8 years later than German, and 3.5 years later than French women of ability. The average age at marriage of Italian and French eminent women is practically the same (21.3 and 21.2 years, respectively).

The average age at which eminent women engaged in thirteen different activities married is shown in the following table. Though we have record of only five reformers we feel fairly confident that the group is justly placed. Only a few American women of the nineteenth century have achieved eminence as social reformers; but American women of ability marry later than those of any other nation, and the average age at marriage in the nineteenth century is later than in any other period of history. The fact that musicians marry 3.1 years later than actresses, and 4.4 years later than artists, seems to indicate that, in many instances, marriage was postponed until a musical reputation had been won. The women who inherited or wedded their right to eminence, that is, the members of the groups "Marriage," "Sovereign" and "Birth" married earlier; where the cases are sufficiently numerous to justify a conclusion it seems that the women who have won by personal effort their right to distinction—the actresses, writers, musicians and reformers—married several years later.

Age at Marriage by Occupation

	Average Age at Marriage	No. Cases on which Average is Based
Reformer	27.4	5
Music	26.7	35
Mistress	26.4	7
Literature	25.7	180
Actress	23.6	32
Religion	22.4	14
Artist	22.3	6
Scholar	21.3	8
Political influence	19.5	14
Mother	19.3	6
Birth	19.3	24
Sovereign	18.9	40
Marriage	18.8	62

Of the eminent women, 520 are known to have married once, 89 married twice, 21 married three times, and Catherine Parr, Joan I. of Naples, Jacqueline of Holland, Lola Montez and Zoe II. were each

married four times. Though the numbers are small, it is of interest to note that 42 per cent. of the group of women who became eminent because of political influence or ability were married more than once. Of the total group of musicians, 30.6 per cent. had more than one husband.

Eminent women have not, on the whole, made particularly successful wives, since 11.6 per cent. of the 781 unions of which we have record have ended in separation or divorce. 36 of the 91 cases of dissolution occurred in families where both husband and wife were famous.

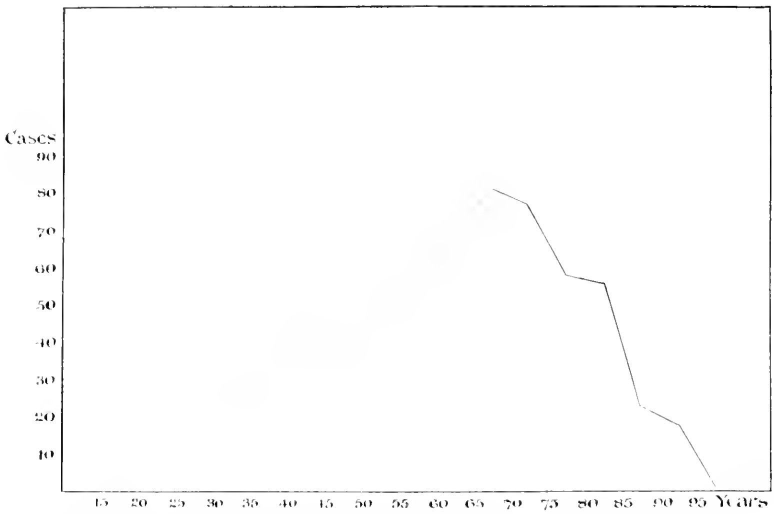
Divorces have been most frequent among distinguished women of German birth. It is barely posible that we have found these results, not because of actual conditions, but because the German encyclopedias are more inclined to give details of domestic life than are those of other nations. The German divorce rate, however, is known to be high. Though much is said about the alarming increase of the rate of divorce in America, it does not hold in the case of eminent women (3 cases).

I have tried to discover whether divorce has been more or less frequent when the husband and wife have been engaged in the same occupation than when their interests were more or less diverse. I hoped to learn whether a singer has been more apt to run into matrimonial shipwreck if she married a composer than if she chose a lawyer for a husband. Has it been safer for a literary woman to marry a scholar or a banker? My figures are not very conclusive, owing to the small number of cases in each occupation, but where a conclusion is warranted, our table tends to show that artists and musicians are safer matrimonially when married to men whose interests are in fields different from their own. In other words, it is better when the husband and wife are not both engaged in an activity which is controlled by temperament and inspiration rather than by reason. In the case of actresses, the percentage of divorce is just the same when the husband is an actor as when he is engaged in some other occupation. With writers, the divorce rate is slightly smaller when the husband is a literary man.

Royal divorces are recorded as remote as the fourth century before Christ. Eminent women not of aristocratic birth have obtained divorces only in the last three centuries.

It has been impossible to discover at what age these women became eminent, but in 670 cases I have been able to ascertain the age at death. Curve IV. represents the age distribution graphically. Both ends of the curve are interesting. Nine women died before they were twenty; nineteen lived to be over ninety. The average length of life is 60.8 years. The slight rise in the curve for eminent women in the twenties, and again in the forties, tends to confirm Galton's conclusion that "among the gifted men there is a small class who have weak and

excitable constitutions, who are destined to early death, but that the remainder consists of men likely to enjoy a vigorous old age."[5] Our cases are so few that we can not lay stress on these periods as being particularly precarious in the case of eminent women.



CURVE IV. DISTRIBUTION OF AGES OF EMINENT WOMEN AT DEATH.

In spite of the fact that in a number of instances the data are too meager to be reliable, it seemed worth while to compute the average age of the eminent women for the different centuries. For the first two centuries after Christ I have only three cases each, but these tend to show that in this remote period, eminent women died early. The martyr's block has left its record in the third century, the average, based on seven cases, being only 28.2 years. Saint Helena escaped a violent death and lived to be 77. If her case were excluded, the average age for the century would be 20.1 years. During the fifth, sixth and seventh centuries the average length of life seems to have been longer. For the remainder of the Middle Ages the figures are so meager as to render them valueless, but from the fourteenth century the numbers are sufficiently large to at least represent a tendency. The average age at death in the case of eminent women of the fourteenth century was 48.7 years; in the fifteenth century, 49.3 years; in the sixteenth century, 49.8 years; in the seventeenth century the average was increased to 60.6 years; in the eighteenth century it was 64.1 years; in the nineteenth century, 62.7 years. This, however, is not a final figure for those of this century who are to be the longest lived and who will tend to increase this average are yet living. It is probable that these aver-

[5] "Hereditary Genius," p. 332, 1869.

ages have no special relation to eminent women, but they seem to show that the advancement of civilization with the increased knowledge of hygiene and the art of living, together with the modern development of medicine and surgery, have cooperated to make it more probable that the days of woman will be prolonged to three score years and ten.

It is of interest to note that the women who have been engaged in social service, the reformers and philanthropists, were the longest lived. The average age of the artists is 66.7 years, and of the actresses 64.5 years. In addition to these, the writers, scholars, politicians and mothers all lived to an average age exceeding that for the entire group. The musicians average 58.4 years; those famous by birth, as sovereigns, mistresses, in religion and by marriage all average less than the group average.

American women of ability are noticeably longer lived than those of any other nation. While this average results in part from the fact that we are a young nation and hence our figures are not affected by early deaths in remoter centuries, it also speaks well for the physical vigor of American women, for our respect for sanitation, and for the skill of American physicians and surgeons. In addition to the American women of eminence, those of Scotland, Germany, Austria and England have lived to more than 60.8 years, the average for the entire group. The women of the Byzantine Empire, of France, Sweden, Holland, Italy, Ireland, Spain, Russia and Rome have failed to attain this average.

Sixty-two, or 7 per cent., of the eminent women of history are known to have suffered violent or unnatural deaths. This bloody chapter began with the tragic death of the Roman girl, Lucretia, in the sixth century before Christ and nineteen centuries are represented in the record. Nineteen of these sixty-two women were Romans; France contributed eight, leading the modern nations in this respect. Sovereigns, or the wives of sovereigns, have been the most frequent victims.

Seventy-two, or 33.1 per cent., of the 217 fathers of the eminent women regarding whom we have been able to collect information, belonged to the so-called learned professions—medicine, teaching, law and the ministry. Our figures tend to show that an eminent daughter has been more apt than not to become distinguished in a line of work similar to that of her father. For example, in the case of sixteen fathers who were musicians, nine of their daughters who achieved fame were also musicians, and two were in the closely related field of acting. Of fifteen fathers who were literary men, fourteen of their eminent daughters were also writers. In considering the similarity of occupation between eminent daughter and father, women of aristocratic extraction have been excluded.

Regarding the cases of relationship that were found to exist be-

tween the eminent women not of noble birth, eighteen of the thirty-eight instances are in the first generation between sister and sister. Fifteen cases occur in the second generation, eight between mother and daughter, and seven between aunt and niece. In the third generation, there are four cases, and in the fifth generation, one case. The figures show a marked tendency for the woman in the younger generation to become eminent in the same, or closely allied line of activity as that in which her eminent relative won distinction.

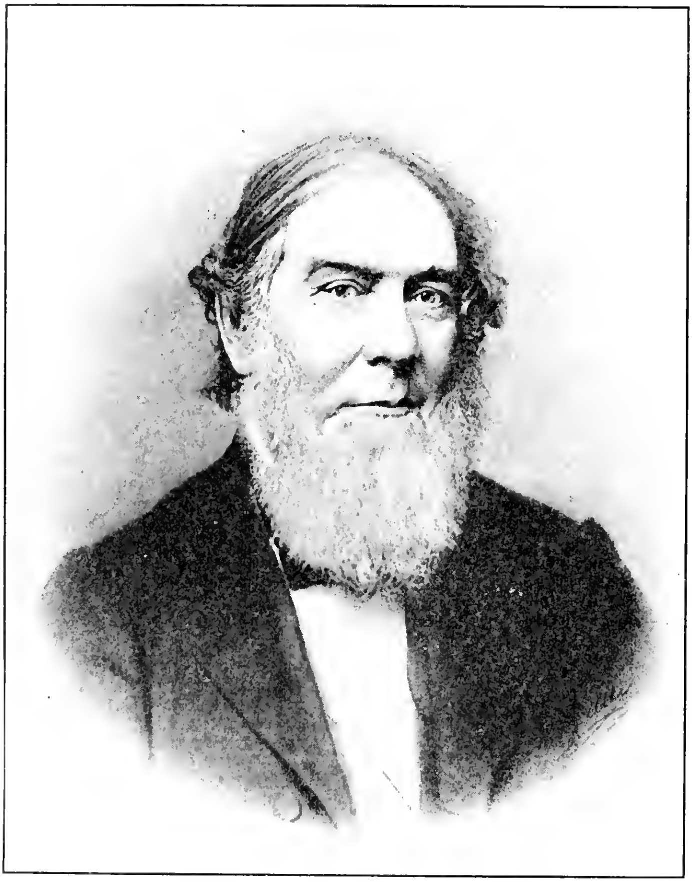
An interesting and suggestive group for consideration is that of the contemporary eminent women. Of these there are 107. The first item of interest is that this group is so large. 12.3 per cent. of the eminent women of history are living at the time this study is made. It required over twenty-five hundred years to produce the remaining 87.7 per cent. This group represents nineteen nationalities, and twelve lines of activity. England, with twenty-two cases, leads in the number of distinguished women of the present generation; Germany and America each claim eighteen; France has twelve, and Italy seven. Austria has six; Sweden, four; Holland, Spain and Hungary, three each; Russia and Poland, two each; and Denmark, Canada, Venezuela, Belgium, Roumania, Scotland and Norway, one each. Canada and Venezuela are represented for the first time in history in the present generation.

In the Old World it is probable that woman will always be able to acquire fame with the wedding ring, and to reign as a sovereign, thus being assured a place in history. If we eliminate those two groups, the fields in which contemporary women are acquiring eminence are, in spite of greater social and educational advantages, and freedom from restriction in many lines, practically limited to three. Fifty-five are writers, twenty are musicians and fourteen are actresses. We wish that we might not have found Jane Addams working alone in the great field of social reform, and that Madame Curie might not have been the only scientist of her generation. In America, where women enjoy greater freedom than in any other part of the globe, there is little evidence of any special results of these advantages. The nation and generation are proud of the achievements of Helen Keller, but one expects that our great educational institutions would produce feminine scholars and teachers of great ability. Possibly, they are in our midst, but like the prophets of old, are without honor in their own generation as well as in their own country.

In order to do justice to this group of eminent women a number of lines of inquiry not yet touched upon deserve to be investigated. Perhaps the most important of these is a study of their children. A knowledge of the number of children born to or reared to maturity by these 634 wives will determine whether in attaining eminence they

sacrificed the function universally accepted as the noblest. It may, perhaps, be shown that whatever they did to perpetuate themselves in history was not at the expense of, but rather in addition to the duties of motherhood. Some correlation, either positive or negative, may be revealed between the size of family and the degree of eminence attained. The number of children who became famous is also of great importance from the standpoint of heredity, and it will at least be interesting to know whether more of them were sons or daughters, and how their fields of life activity agreed with or differed from that of their mothers.

A study of the state of health and cause of death may reveal much needed information as to whether female genius differs physically or physiologically from others of her sex. The relative variability of the sexes is a matter of prime importance in a study of female ability, as is also the question of psychical sex differences. Thorough examination of the social and educational environment of this group of eminent women is not only desirable, but essential in understanding them as the historical representatives of their time. The relative productivity of the aristocracy, and a careful social classification ought to be made. Women have not always had the advantages they now enjoy. It is not probable that the female voice has varied in sweetness through the ages, yet it was not until the eighteenth century that we have record of a noted songstress. Have we any reason to believe that when women have gained all the rights and privileges for which they now clamor that any significant results will follow? Is there a biological limitation which says to the female, "Thus far shalt thou go and no farther"? While we may never be able to settle these questions definitely, a just and thorough consideration of all the points of approach will, we trust, enable us to answer with some degree of certainty the question which we propounded at the beginning of our study, and which has haunted us throughout the research, namely, has innate inferiority been the reason for the small number of eminent women, or has civilization never yet allowed them an opportunity to develop their innate powers and possibilities?



A. D. Bache

THE PROGRESS OF SCIENCE

THE ANNIVERSARY MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences celebrated the semi-centennial anniversary of its foundation on April 22, 23 and 24, exactly fifty years after its first meeting. It was a most successful meeting with the largest attendance of members in the history of the academy. There was no program of technical papers, but in its place a series of addresses. Dr. Ira Remsen, the president of the academy, at the first session read an address on the history of the academy, and then introduced President Arthur T. Hadley, of Yale University, who spoke on "The Relation of Science to Higher Education in America." In his usual happy style he traced the increased part played by science in modern education and pointed out that his father, James Hadley, taught Greek at Yale more in accord with the methods of modern science, than was the case with physics, chemistry and biology in those days. James Hadley was elected to membership in the academy the year after its foundation, followed two years later by the election of another distinguished Yale philologist, William Dwight Whitney. There were also eminent economists in the academy, and the question may fairly be raised, though President Hadley did not do so, whether it would not be better for the academy to include in its scope the philosophical, historical and political sciences, instead of confining the membership to the natural and exact sciences.

The second formal address was read by Dr. Arthur Schuster, secretary of the Royal Society of London, who discussed "International Cooperation in Research." He stated that the strength of modern science lies not so much in the production of commanding genius as in an army of competent investigators. Problems in which useful results have already been obtained by international cooperation were reviewed, but scarcely in the "great variety" promised at the beginning of the address, for only those were mentioned in which the speaker was personally interested; all those concerned with the biological sciences, and most of those concerned with the exact sciences and their applications being ignored. The three categories of scientific cooperation mentioned—namely, the agreements on units of measurement, the distribution of work between different nations for economy and the making of similar observations with similar instruments—cover but a small part of the field. Still the subjects reviewed—the Star Catalogue; the International Catalogue of Scientific Literature; Geophysics, and the Solar Union—illustrate sufficiently the advantages, and, it may be added, the difficulties, of international cooperation. Dr. Schuster perhaps went out of his way to ridicule the Belgian scheme for international associations and is too hopeful as to what the International Association of Academies may accomplish. Academies, national and international, must be placed on a representative democratic basis before they can represent the scientific men and the scientific work of the nation or of the world.

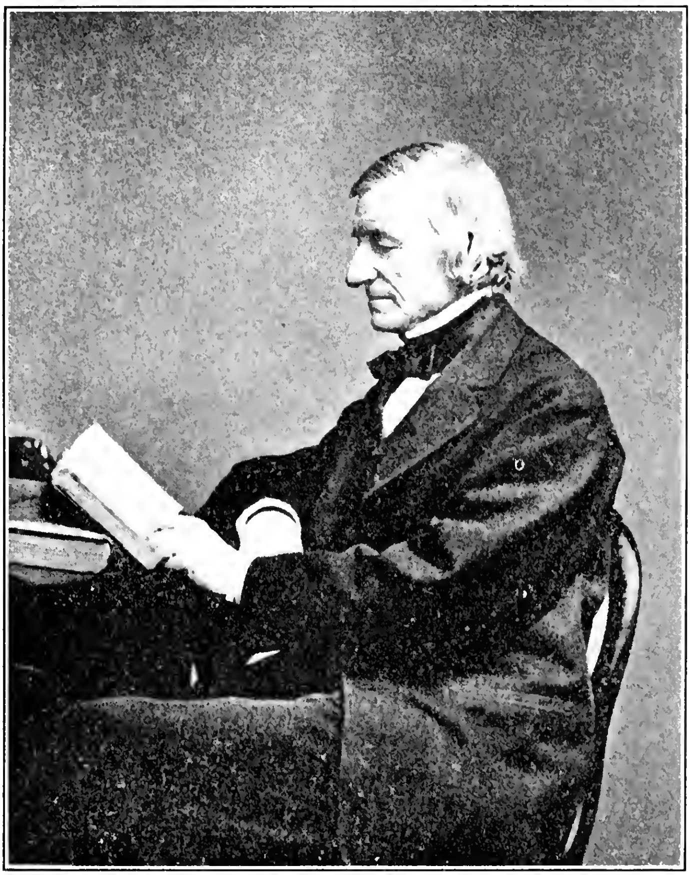
The two other addresses were on special scientific problems to which their authors have made distinguished contributions. Dr. George E. Hale, director of the Mt. Wilson Solar Observatory, had as his subject "The Earth and Sun as Magnets"; Dr. J. C. Kapteyn, director of the astronomical laboratory of the University of Groningen, "The Structure of the Universe." Both of these addresses

treated with admirable clearness wide-reaching theories to which the writers had in large measure contributed both the facts and the deductions. Dr. Hale's address will be printed in THE POPULAR SCIENCE MONTHLY. The other addresses have been or will be printed in *Science*.

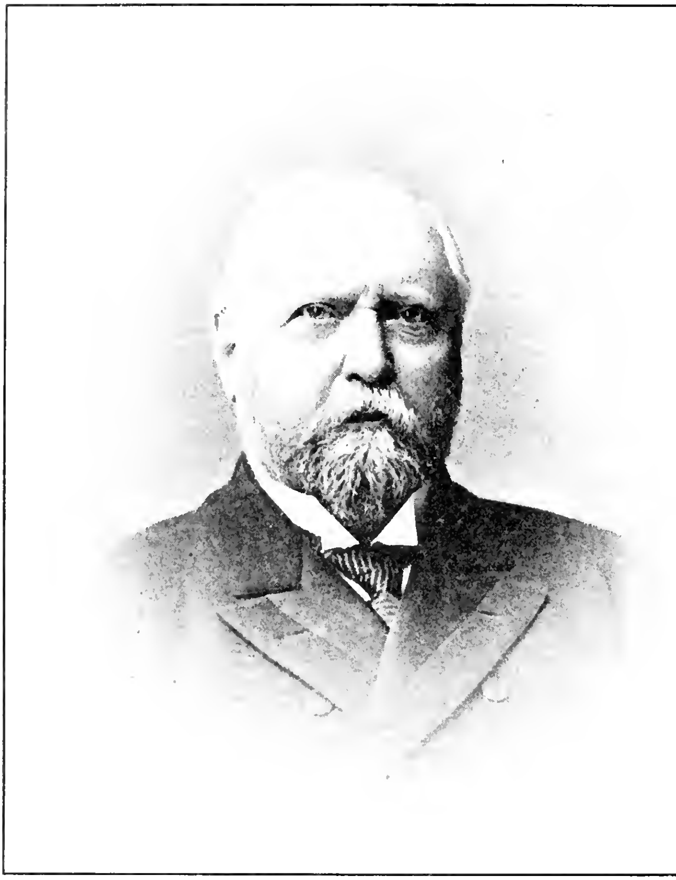
Dr. Theodor H. Boveri, of the University of Würzburg, was to have spoken on "The Material Basis of Heredity," but was unable to be present owing to ill health. Otherwise the program would have represented education and the sciences of conduct, the organization of science, and the exact and biological sciences, with two addresses from home and three addresses from abroad. The fact that three out of the four addresses were given by men working in astronomy and geophysics represents a real popular interest, though perhaps a survival from a more superstitious period, when the

motions of the stars were supposed to exert more control over human welfare than, for example, the prevention of disease by scientific research.

The program left ample time for social events, which were admirably arranged. Luncheons were provided each day and there were evening receptions at the National Museum and the Carnegie Institution. The afternoon of April 24 was devoted to an excursion to Mt. Vernon on the U. S. S. *Mayflower*. On the afternoon of April 23, there was a reception at the White House, when the President of the United States conferred medals, and afterwards, with Mrs. Wilson, received and entertained the members of the academy and their guests. The Watson medal for astronomical research was presented to Dr. J. C. Kapteyn, the Draper medal for astrophysical research to the French Ambassador for M. Henri Deslandres, the Agassiz medal for oceanographical research to the Norwegian minister for Dr. Johan Hjört, and the Comstock prize of the value of $1,500 for research in radiant energy, to Professor R. A. Millikan, of the University of Chicago. At the dinner on the evening of April 24 speeches were made by the vice-president of the



William B Rogers



O. C. Marsh

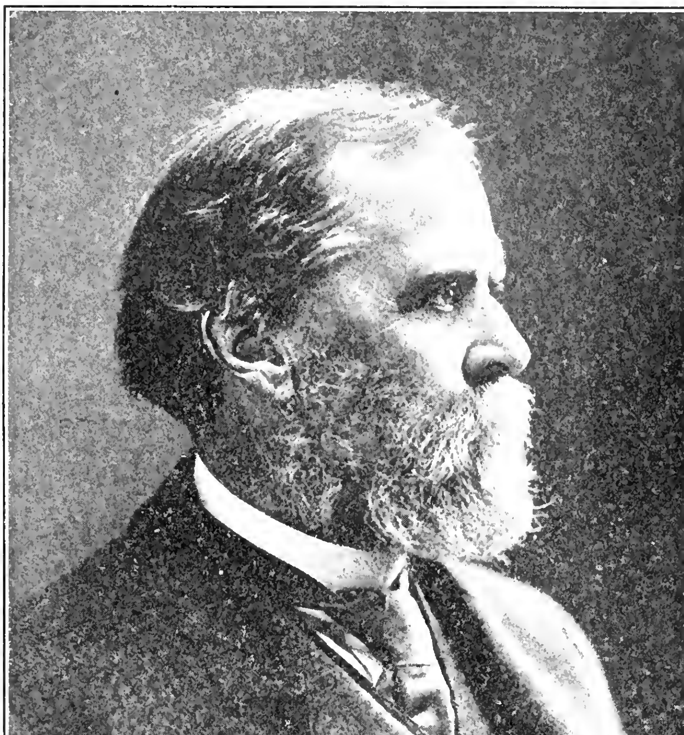
United States, the British Ambassador, Dr. S. Weir Mitchell, Dr. W. W. Keen, president of the American Philosophical Society, and Senator Burton.

THE HISTORY OF THE NATIONAL ACADEMY

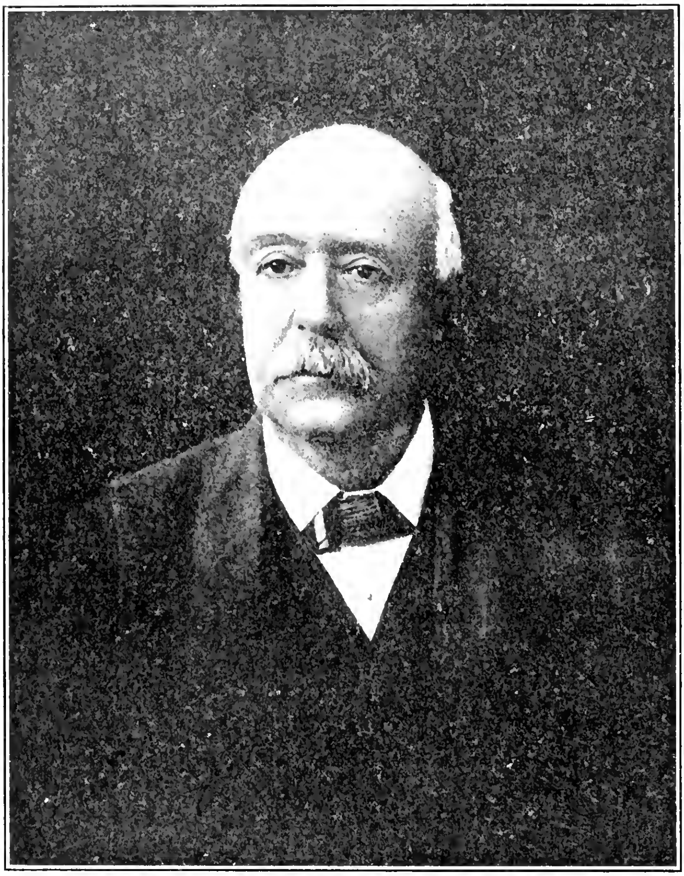
THE National Academy of Sciences was founded under the shadow of the civil war in order that the government might have the benefit of expert scientific advice and—as has usually been the reward of scientific research—obtain it free of cost. In February, 1863, the secretary of the navy appointed a "permanent commission," consisting of Joseph Henry, secretary of the Smithsonian Institution; Alexander Dallas Bache, superintendent of the Coast Survey, and Charles H. Davis, chief of the Bureau of Navigation, to report on "matters of science and art." This commission led to the establishment of the National Academy of Sciences through a bill introduced in the senate by Henry Wilson, of Massachusetts, on February 20, 1863, and signed by President Lincoln on March 3.

The idea of a national academy was

not new; it had, for example, been advocated by Bache in his presidential address before the American Association for the Advancement of Science in 1851. Such academies existed in each of the great foreign nations and had been important factors in the advancement of science, through their relation to the government and in other directions. The Royal Society of London celebrated last year its two hundred and fiftieth anniversary; the Academy of Sciences of Paris was established at about the same time; even earlier there were academies in Italy. The members of the continental academies receive salaries; the British government at least provides the Royal Society with a house. In this country the American Philosophical Society, modeled by Franklin on the Royal Society, and the American Academy of Arts and Sciences, modeled by Adams on the Paris Academy, have long histories. If Philadelphia had remained the seat of government, the American Philosophical Society would doubtless have performed the functions of a national academy.



Wolcott Gibbs

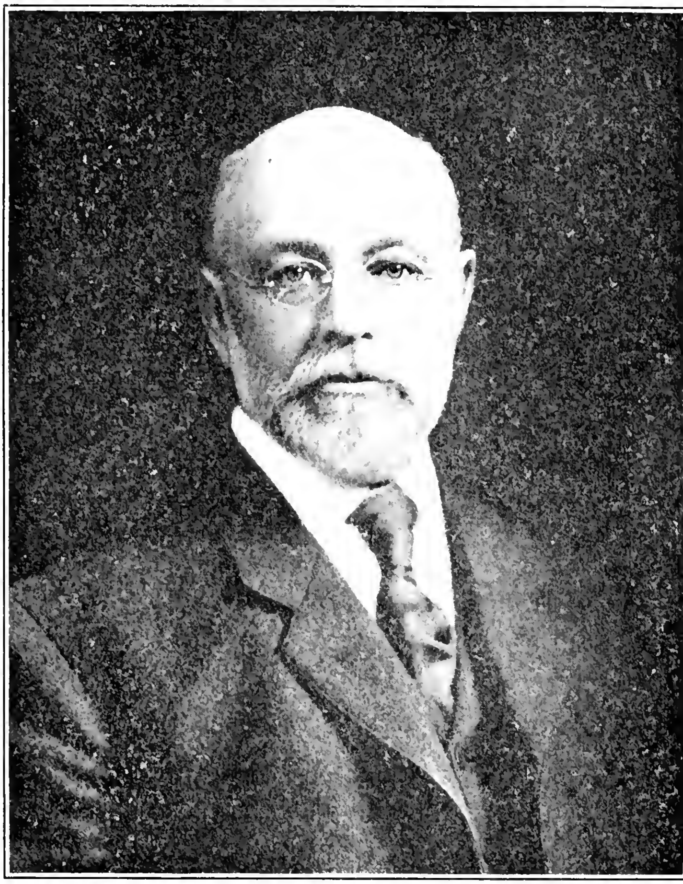


A. Agassiz

There were fifty original members of the National Academy and until 1870 the membership was limited to that number. The first meeting was held at the University of the City of New York, now New York University, on April 22, 1863. The officers were: president, Alexander Dallas Bache; vice president, James Dwight Dana; foreign secretary, Louis Agassiz; home secretary, Wolcott Gibbs; treasurer, Fairman Rogers. The academy was divided into two classes, one for mathematics and physics, of which Benjamin Peirce was chairman and Benjamin A. Gould secretary, and one for natural history, of which the elder Benjamin Silliman was chairman and J. S. Newberry secretary. It is doubtful whether the academy could now elect officers who fifty years hence would be equally distinguished.

Immediately after its organization the academy was called upon to appoint committees to advise the government, five such committees being named within a month. The first of these was on uniformity of weights, measures and coins considered in relation to international commerce. This committee ultimately reported in favor of making it lawful to use the metric system and

to authorize its use in the postoffice and this recommendation was enacted into law by the congress. Other committees, as on protecting the bottoms of iron vessels and on magnetic deviation of iron ships, were directly concerned with the conduct of the civil war. As the scientific bureaus of the government developed there became less need of committees of the academy for investigation, and, as the president pointed out in his introductory address at the recent celebration, the government has in recent years but rarely called on the academy for its advice. The last time the academy acted was in pursuance of a request by the congress in 1908 to report on the methods and expenses of conducting the scientific work under the government, but the recommendations of this committee appear to have been ignored. There is reason to believe that while committees for conducting scientific experiments are no longer needful, the disinterested advice of a body such as the National Academy in the selection of the heads of the scientific bureaus under the government and the conduct of their work may be recognized. The officers elected



Ira Remsen

at the recent anniversary meeting—Dr. William H. Welch, professor of pathology at the Johns Hopkins University, president; Dr. Charles D. Walcott, secretary of the Smithsonian Institution, vice-president; and Dr. A. L. Day, director of the Geophysical Laboratory of the Carnegie Institution, home secretary—promise an administration under which the advice of the academy may be of service to the government.

On the occasion of the fiftieth anniversary there has been published a history of the first half century of the academy, prepared and edited by Dr. Frederick W. True, assistant secretary of the Smithsonian Institution under the charge of a committee of which Dr. Arnold Hague, the home secretary, was chairman. From this volume we take the portraits of the seven distinguished men of science who have successively been presidents of the academy.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Lester F. Ward, professor of sociology at Brown University, formerly paleontologist of the U. S. Geological Survey, and of Professor William Morris Fontaine, for thirty-one years professor of natural history and geology in the University of Virginia.

Under the present admistration Dr. B. T. Galloway, chief of the Bureau of Plant Industry, has been appointed assistant secretary of agriculture and Professor Adolph C. Miller, who holds the chair of economics and commerce in the University of California, first assistant secretary of the interior. Dr. Hugh M. Smith has been promoted to be commissioner of fisheries. Dr. John Bassett Moore, professor of international law and diplomacy in Columbia University, has been appointed counsellor to the department of state.

The National Academy of Sciences has elected the following new members: Henry Andrews Bumstead, professor of physics, Yale University; L. E. Dickson, professor of mathematics, University of Chicago; Ross G. Harrison, professor of comparative anatomy, Yale University; Gilbert Newton Lewis, professor of physical chemistry, University of California; A. O. Leuschner, professor of astronomy, University of California; Lafayette B. Mendel, professor of physiological chemistry, Yale University; George H. Parker, professor of zoology, Harvard University; L. V. Pirsson, professor of geology, Yale University; Edward B. Rosa, chief physicist, Bureau of Standards; Erwin F. Smith, pathologist in charge, Bureau of Plant Industry, U. S. Department of Agriculture.

The American Philosophical Society at its stated meeting on April 19 elected the following members: Dr. George F. Atkinson, professor of botany, Cornell University; Dr. Charles Edwin Bennett, professor of the Latin language and literature, Cornell University; Dr. John Henry Comstock, professor of entomology and invertebrate zoology, Cornell University; Luther P. Eisenhart, professor of mathematics, Princeton University; George Washington Goethals, U.S.A., chief of engineers of the Panama Canal; William Crawford Gorgas, assistant surgeon general, U.S.A.; Dr. Ross Granville Harrison, professor of comparative anatomy, Yale University; George Augustus Hulett, professor of physical chemistry, Princeton University; Dr. Clarence Erwin McClung, professor of zoology, University of Pennsylvania; John Dyneley Prince, professor of Semitic languages, Columbia University; Dr. Samuel Rea, president of the Pennsylvania Railroad Company; Dr. Henry Norris Russell, professor of astronomy, Princeton University; Witmer Stone, curator of ornithology of the Philadelphia Academy of Natural Sciences. Three foreign members were elected as follows: Sir Arthur John Evans, keeper of the Ashmolean Museum, Oxford; Sir Joseph Larmor, Lucasian professor of mathematics, Cambridge; and Dr. Arthur Schuster, secretary of the Royal Society, London.

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